UNCLASSIFIED

AD NUMBER
ADC034019

CLASSIFICATION CHANGES

TO: unclassified

FROM: confidential

LIMITATION CHANGES

TO:

Approved for public release, distribution unlimited

FROM:

Distribution limited to U.S. Gov't. agencies only; Test and Evaluation; 12 Apr 84. Other requests must be referred to the Commanding Officer, NORDA, NSTL Station, MS 39529.

AUTHORITY

ONR ltr., Ser 93/160, 10 Mar 1999; SAME

THIS PAGE IS UNCLASSIFIED

AD-E001570

CONFIDENTIAL

(3)

NORDA Report 35
Book 2 of 3

The Acoustic Model Evaluation Committee (AMEC) Reports

Volume II, Appendices A-D

The Evaluation of the FACT PL9D Transmission Loss Model (U)

Prepared by Richard B. Lauer

Environmental Requirements and Program Analysis Group
Ocean Science and Technology Laboratory

AD C034019

September 1982

DEPARTMENT OF THE NAVY NAVAL OCEAN R&D ACTIVITY

Distribution limited to U.S. Government agencies only. T&E 12 APR 1984
Other requests for this document must be referred to the Commanding Officer, Naval Ocean Research and Development Activity, NSTL Station, Mississippi 39529

Classified by OPNAVINST 5513.5 (3) Declassify on ~~31 December 1990~~ OADR

DTIC FILE COPY

Including the Physics of the Fact PL9D Model
prepared by Charles L. Bartberger
Naval Air Development Center

DTIC ELECTE APR 1 2 1984 S D B

Naval Ocean Research and Development Activity
NSTL Station, Mississippi 39529

CONFIDENTIAL

84 04 06 508

Appendix IIA. Accuracy Assessment of FACT PL9D Compared to SUDS Experimental Data (U)

SUDS I (U)

Environment (U)

(C) All environmental measurements come from station 1 of the SUDS I measurements. Three sound speed profiles, given in Figures IIA1-IIA3, represent average conditions during three measurement periods. These sound speed profiles, in accordance with Martin (1981), will be referred to as profiles A, E, and B. Profile A has a surface duct to a depth of 68 m overlying a sound channel with axis at 900 m. Profile E is an average profile with a 20 m surface duct, a subsurface channel with axis at 200 m and a deep sound channel with axis at 900 m. Profile B has a surface duct to a depth of 79 m and a deep sound channel with axis at 900 m.

(C) The source used pulsed energy, and bottom bounce arrivals were temporarily filtered out. The effective bottom loss for model input should therefore be dB (actually, a bottom loss of 50 dB was entered for all grazing angles).

Test Cases (U)

(C) The 12 test cases selected from SUDS I experimental data for use in model evaluation are as follows:

In this table, R_{min} is the minimum range at which data is found, R_{max} is the maximum range and SSP denotes sound speed profile.

(U) Both source and receiver are in the surface duct for cases I, III, IX, and XI. Source and receiver are across the duct from one another in cases II, IV, V, VII, X, and XII. Both source and receiver are below the duct for cases VI and VIII. The experimental data for the twelve test cases are plotted in figures IIA-4 through IIA-15.

Accuracy Assessment Results (U)

(U) The accuracy assessment procedures were followed as outlined in section 1.1 and described in detail in section 5 of Volume I of this series. The following figures are given for each case: (1) FACT PL9D output using the semicoherent option and (2) the FACT PL9D semicoherent result subtracted from the SUDS data. These are presented in pairs as Figures IIA16-IIA39. The coherent FACT PL9D plots are given in Figures IIA40-IIA51 and incoherent results in Figures IIA52-IIA63. As the reader can verify, the three phase addition options led to essentially the same result. Difference curves and their associated statistics are not presented for incoherent and

CASE	SOURCE DEPTH (m)	RECEIVER DEPTH (m)	FREQUENCY (kHz)	R_{min} (km)	R_{max} (km)	NO. OF POINTS	SSP	WIND SPEED (kn)
I	45	17	0.4	2.0	24.5	925	A	11
II	45	112	0.4	2.0	17.4	625	A	11
III	42	43	1.0	2.0	24.4	959	A	11
IV	42	112	1.0	2.0	24.8	818	A	11
V	41	6	1.5	0.4	24.6	796	E	4
VI	41	59	1.5	0.4	24.8	811	E	4
VII	41	6	2.5	0.4	24.8	868	E	4
VIII	41	59	2.5	0.4	24.8	866	E	4
IX	45	17	3.5	0.1	35.3	1311	B	6
X	45	112	3.5	0.1	35.8	918	B	6
XI	42	17	5.0	0.1	35.5	1421	B	6
XII	42	112	5.0	0.1	33.8	959	B	6

coherent model results; they were calculated and found to be essentially identical to the semicoherent results. For the same reason, the figure of merit analysis was applied to only the FACT PL9D semicoherent output. The means and standard deviations of the differences between the SUDS data and the FACT PL9D semicoherent output are given in Table IIA1.

(C) For Cases I and II (400 Hz) the SUDS data shows the cross layer Case II to sustain 15 dB greater loss than the in-layer Case I. The corresponding figure for FACT results was 5 dB. The problem seems to rest primarily with Case I as is evident from the pertinent values of means and standard deviations. The difference curve for Case I shows a 5-10 dB negative offset (which, as we shall see below, translates into pessimistic range predictions) to a range of 10 km. From 16 km onward the trend is toward positive difference with the curve crossing zero at 18 km. For Case II, the difference curve shows no dominant trend. At 1 kHz, Case III is an in-layer case and Case IV has cross-layer geometry. To a range of 7 km the difference between the SUDS data for the two cases is 10 dB; beyond that the difference increases to 20 dB, the cross-layer case, of course, exhibiting the greater loss. The model results show a difference of 5 dB at short ranges, increasing steadily to 15 dB at 25 km. The difference curves reveal basically the same behavior for both cases to a range of 7 km. Beyond that, Case III shows a generally negative bias and Case IV a positive bias with a negative trend. For Case III, differences are largely due to the model's lack of an interference structure found in the experimental results. At 1.5 kHz, Case V is a cross-layer case and Case VI is a below-layer case. The experimental data are roughly similar to a range of 12 km. From that point on, a difference of approximately 10 dB is found with the below-layer loss greater. The model results show a monotonically growing difference which eventually reaches 10 dB at 25 km. In both cases the experimental data have significant interference patterns and the model does not. The differences are primarily due to this factor in Cases VII and VIII, at 2.5 kHz, Case VII has a cross-layer and Case VIII a below-layer source/receiver geometry. The below-layer curve has an ever-widening difference from the in-layer curve to about 20 dB at 24 km for the SUDS data and both curves show a substantial interference pattern. In case VIII, the experimental data shows a decrease in loss from 14 to 24 km. The model shows a monotonic increase over the full range extent. For these cases there appears to be no correspondence between experimental findings and model predictions. This finding holds *a fortiori* for in-layer Case IX at 3.5 kHz. The cross-layer Case X at 3.5 kHz shows good correspondence between model and SUDS data between 3 and 10 km. In this case the SUDS data show no interference pattern but are characterized by ± 5 dB fluctuations (except where clipped at 95 dB). The model results show no fluctuations. The 5 kHz Cases XI and XII are present in-layer and cross-layer source/receiver geometries, respectively. In both cases, a strong trend in the difference curve shows a basically different falloff range between SUDS data and FACT output. FACT fails to capture the interference pattern of Case XI or the fluctuations of Case XII (similar to Cases IX and X).

(C) Now, let us turn to the Figure of Merit (FOM) analysis. FOM versus detection range is tabulated for SUDS data and FACT semicoherent results at 5 dB increments for the twelve cases in Tables IIA2-IIA13. For Case I, the model predicts pessimistic detection range coverage compared to SUDS data for FOMs <85 dB; for FOMs between 85 and 95 dB agreement between FACT output and SUDS data is close. For Case II, results are in basic agreement between FACT and SUDS. This is not surprising upon noting the relatively small mean and standard deviation of differences for this case. For Case III, FACT is consistently pessimistic in detection range estimates.

Case IV shows basic agreement in detection range between model results and experimental data. In Case V, agreement is found for FOMs less than 80 dB. Past 80 dB the SUDS data show increasingly greater coverage that is zonal as compared to FACT which has no interference structure and therefore no zonal coverage. This same result is obtained for Case VI where the disagreements are found for FOMs equal to or greater than 90 dB. In Case VII there is no correspondence between SUDS data and FACT output. For FOMs less than 80 dB FACT is optimistic, and at past 80 dB SUDS data are zonal in detection coverage due to interference patterns and overall, FACT is pessimistic at these FOMs. The initially lower loss values for FACT in Case VIII result in optimistic detection range predictions for FOMs up to and including 95 dB. For FOMs $\geq$ 100 dB, model output and experimental data are in basic agreement (somewhat fortuitous, however, considering FACT's lack of interference pattern as compared to SUDS data). Cases IX and X exhibit no correspondence between model and experiment, FACT being consistently pessimistic (by factors as great as 6 for Case IX and 2 for Case X). In Case XI the range errors increase with increasing FOM and interference patterns in SUDS data result in zonal detection coverage. FACT predicts short ranges compared to SUDS data. For Case XII basic agreement is found through FOM = 70 dB; for FOMs from 75-95 dB FACT predicts optimistic ranges; for FOM 100 dB, FACT predicts pessimistic detection ranges.

(C) From the above, the following general conclusions may be reached: (1) Regardless of source/receiver geometry with respect to the surface duct, agreement is generally lacking between FACT PL9D results and SUDS data. (2) This is particularly notable in FACT's inability to reproduce either fluctuations or interference patterns observed in the SUDS data. (3) The basically identical results for FACT regardless of coherence option chosen indicates a need for closely examining this aspect of the model. (4) It would appear that FACT requires a new surface duct module which includes leakage and rough surface effects.

References (U)

1. Martin, R. L. et al. The Acoustic Model Evaluation Committee (AMEC) Reports, Volume IA (1982). Summary of Range Independent Environmental Acoustic Propagation Loss Data Sets (U). Naval Ocean Research and Development Activity Report No. 34. CONFIDENTIAL

(U) Table IIA-1. Means (μ) and Standard Deviations (σ) of Differences Obtained by Subtracting Fact PL9D Semicoherent Outputs From Suds I Experimental Data (in dB)

Case	μ	σ
I	-5.9	6.0
II	1.2	2.7
III	-1.8	3.0
IV	6.1	4.8
V	-2.5	7.3
VI	-0.2	5.2
VII	5.8	11.8
VIII	9.3	8.5
IX	-17.6	7.6
X	-8.1	6.2
XI	-5.6	8.7
XII	3.4	9.2

CONFIDENTIAL

(C) Table IIA-2 Detection Range (km) as a Function of Figure of Merit (dB) for SUDS I Data and FACT PL9D Model Results.
Case I:
(Station 1, Run 3, Source Depth = 45 m Receiver Depth = 17 m, Frequency = 400 Hz

DATA SET	FOM	R_c[1]	RANGE $> R_c$
SUDS	60	-	
FACT PL9D	60	0.5	
SUDS	65	9.0	
FACT PL9D	65	2.0	
SUDS	70	12.0	
FACT PL9D	70	4.5	
SUDS	75	15.5	
FACT PL9D	75	8.0	
SUDS	80	17.0	
FACT PL9D	80	13.0	
SUDS	85	18.5	
FACT PL9D	85	18.0	
SUDS	90	19.5	
FACT PL9D	90	23.0	
SUDS	95	20.5	ZDC[2] 70%, 20.5-24 km
FACT PL9D	95	>24.0	

1. R_c = Range to which detection coverage is continuous.

2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval over which detection is possible.

CONFIDENTIAL

(C) Table IIA-3. Detection Range (km) as a Function of Figure of Merit (dB) for SUDS I Data and FACT PL9D Model Results.
Case II:
(Station 1, Run 3, Source Depth = 45 m, Receiver Depth = 112 m, Frequency = 400 Hz)

DATA SET	FOM	R_c [1]	Range > R_c
SUDS	70	-	
FACT PL9D	70	2.5	
SUDS	75	-	ZDC[2] 90%, 1.5-6.5 km
FACT PL9D	75	4.5	
SUDS	80	7.0	
FACT PL9D	80	7.0	
SUDS	85	7.5	ZDC 15%, 7.5-13 km
FACT PL9D	85	11.5	
SUDS	90	10.5	ZDC 70%, 10.5-14.5 km
FACT PL9D	90	16.0	
SUDS	95	16.5	
FACT PL9D	95	>16.5	

1. R_c = Range to which detection coverage is continuous.
2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval over which detection is possible.

CONFIDENTIAL

(C) Table IIA-4. Detection Range (km) as a Function of Figure of Merit (dB) for SUDS I Data and FACT PL9D Model Results. Case III: (Station 1, Run 4, Source Depth = 42 m, Receiver Depth = 43 m, Frequency = 1 kHz)

DATA SET	FOM	R_c [1]	RANGE > R_c
SUDS	60	-	ZDC[2] 75%, 2-3 km
FACT PL9D	60	1.5	
SUDS	65	3.5	ZDC 15%, 3.5-5.5 km
FACT PL9D	65	3.0	
SUDS	70	6.0	ZDC 50%, 7.5-13.5 km
FACT PL9D	70	7.0	
SUDS	75	7.0	100% coverage, 7.5-17.5 with one dropout at 15 km
FACT PL9D	75	11.5	
SUDS	80	21.5	ZDC 60%, 21.5-24.5 km
FACT PL9D	80	>24.5	

1. R_c = Range to which detection coverage is continuous.

2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval over which detection is possible.

CONFIDENTIAL

(C) Table IIA-5. Detection Range (km) as a Function of Figure of Merit (dB) for SUDS I Data and FACT PL9D Model Results. Case IV: (Station 1, Run 4, Source Depth = 42 m, Receiver Depth = 112 m, Frequency = 1 kHz)

DATA SET	FOM	R_c[1]	Range > R_c
SUDS	70	-	ZDC[2] 15%, 2-3.5 km
FACT PL9D	70	2.5	
SUDS	75	2.5	ZDC 90%, 2.5-5 km
FACT PL9D	75	4.5	
SUDS	80	5.5	ZDC 80%, 5.5-6.5 km
FACT PL9D	80	7.0	
SUDS	85	7.0	
FACT PL9D	85	11.0	
SUDS	90	7.0	ZDC 5%, 7-15 km
FACT PL9D	90	16.0	
SUDS	95	8.0	ZDC 40%, 8-16.5 km
FACT PL9D	95	20.0	
SUDS	100	8.5	ZDC 80%, 8.5-16.5 km; ZDC 50%, 16.5-18.5 km; ZDC 20%, 18.5-24.5 km
FACT PL9D	100	>24.5	

1. R_c = Range to which detection coverage is continuous.
2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval over which detection is possible.

CONFIDENTIAL

(C) Table IIA-6. Detection Range (km) as a Function of Figure of Merit (dB) for SUDS I Data and FACT PL9D Model Results.
Case V:
(Station 1, Run 1, Source Depth = 41 m, Receiver Depth = 6 m, Frequency = 1.5 kHz)

DATA SET	FOM	R_c [1]	Range $> R_c$
SUDS	60	-	ZDC[2] 50%, 0.5-2.0 km
FACT PL9D	60	1.0	
SUDS	65	-	100% coverage, 0.5-2.5 km
FACT PL9D	65	2.5	
SUDS	70	-	100% coverage, 0.5-4 km
FACT PL9D	70	4.5	
SUDS	75	-	100% coverage, 0.5-5 km; ZDC 50%, 5-6 km
FACT PL9D	75	7.5	
SUDS	80	-	100% coverage, 0.5-8 km and 19.5-22 km
FACT PL9D	80	10.5	
SUDS	85	9.0	ZDC 35%, 9-11.5 km; ZDC 90%, 11.5-18 km; 100% coverage, 19-22.5 km
FACT PL9D	85	14.0	
SUDS	90	9.0	100% coverage, 9.5-11, 11.5-18, 18.5-23; ZDC 50%, 23-24.5 km
FACT PL9D	90	17.5	

1. R_c = Range to which detection coverage is continuous.

2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval over which detection is possible.

CONFIDENTIAL

(C) Table IIA-7. Detection Range (km) as a Function of Figure of Merit (dB) for SUDS I Data and FACT PL9D Model Results.
Case VI:
(Station 1, Run 1, Source Depth = 41 m, Receiver Depth = 59 m, Frequency = 1.5 kHz)

DATA SET	FOM	R_c[1]	RANGE $> R_c$
SUDS	60	-	ZDC[2] 30%, 0.5-2 km
FACT PL9D	60	1.0	
SUDS	65	-	ZDC 50%, 0.5-3 km
FACT PL9D	65	2.0	
SUDS	70	-	ZDC 70%, 0.5-3.5 km
FACT PL9D	70	3.5	
SUDS	75	-	ZDC 85%, 0.5-3.5 km
FACT PL9D	75	3.5	
SUDS	80	5.0	100% coverage, 7-7.5 km
FACT PL9D	80	7.0	
SUDS	85	5.0	100% coverage, 6.5-8 km
FACT PL9D	85	7.5	
SUDS	90	5.0	ZDC 85%, 5-11 km; ZDC 85%, 11.5-12.5 km; ZDC 30%, 14-16.5 km
FACT PL9D	90	10.5	
SUDS	95	11.0	ZDC 85%, 11-18 km; ZDC 85%, 20-22 km
FACT PL9D	95	14.5	
SUDS	100	11.5	ZDC 95%, 11.5-18 km; ZDC 10%, 18-20.5 km; ZDC 90%, 20-22.5 km; ZDC 20%, 22.5-25 km
FACT PL9D	100	19.0	

1. R_c = Range to which detection coverage is continuous.

2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval over which detection is possible.

(C) Table IIA-8 Detection Range (km) as a Function of Figure of Merit (dB) for SUDS I Data and FACT PL9D Model Results.
Case VII:
(Station 1, Run 2, Source Depth = 41 m, Receiver Depth = 6 m, Frequency = 2.5 kHz)

DATA SET	FOM	R_c[1]	RANGE > R_c
SUDS	65	-	ZDC[2] 10%, 0-1 km
FACT PL9D	65	2.5	
SUDS	70	-	ZDC 60%, 0-1 km
FACT PL9D	70	4.5	
SUDS	75	-	ZDC 50%, 0-2 km
FACT PL9D	75	7.0	
SUDS	80	-	ZDC 70%, 0-4 km; 100% coverage 21-22 km
FACT PL9D	80	10.0	
SUDS	85	1.0	ZDC 95%, 1-4 km; 100% coverage, 17.5-18.5 and 20-23 km
FACT PL9D	85	13.5	
SUDS	90	4.0	ZDC 10%, 4-11 km; ZDC 90%, 15.5-23.5 km
FACT PL9D	90	17.0	
SUDS	95	6.0	ZDC 80%, 6-17 km; ZDC 90%, 17-24 km
FACT PL9D	95	20.5	

1. R_c = Range to which detection coverage is continuous.

2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval over which detection is possible.

CONFIDENTIAL

(C) Table IIA-9. Detection Range (km) as a Function of Figure of Merit (dB) for SUDS I Data and FACT PL9D Model Results.
CASE VIII:
(Station 1, Run 2, Source Depth = 41 m, Receiver Depth = 59 m, Frequency = 2.5 kHz)

DATA SET	FOM	R_c [1]	Range > R_c
SUDS	70	-	ZDC[2] 15%, 0-1 km
FACT PL9D	70	3.5	
SUDS	75	-	ZDC 20%, 0-1 km
FACT PL9D	75	3.5	
SUDS	80	-	ZDC 50%, 0-2 km
FACT PL9D	80	6.0	
SUDS	85	-	ZDC 60%, 0-3 km
FACT PL9D	85	7.5	
SUDS	90	-	ZDC 80%, 0-4 km
FACT PL9D	90	10.5	
SUDS	95	4.0	ZDC 50%, 4-5 km; ½ km coverage at 8 and 22 km
FACT PL9D	95	14.5	
SUDS	100	5.0	ZDC 60%, 5.0-8.5 km; ZDC 50%, 11-18 km; ZDC 30%, 20.5-23 km
FACT PL9D	100	18.0	
SUDS	105	6.0	ZDC 90%, 6-8.5 km; ZDC 20%, 8.5-11 km; ZDC 90%, 11-18.5 km; ZDC 75%, 20-23.5 km
FACT PL9D	105	21.5	
SUDS	110	6.0	ZDC 95%, 6-18.5 km; ZDC 50%, 18.5-20 km; ZDC 95%, 20-24 km
FACT PL9D	110	24.5	
SUDS	115	19.0	ZDC 90%, 19-24.5 km
FACT PL9D	115	>24.5	

1. R_c = Range to which detection coverage is continuous.

2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval over which detection is possible.

(C) Table IIA-10. Detection Range (km) as a Function of Figure of Merit (dB) for SUDS I Data and FACT PL9D Model Results.
CASE IX:
(Station 1, Run 5, Source Depth = 45 m, Receiver Depth = 17 m, Frequency = 3.5 Hz)

DATA SET	FOM	R_c[1]	Range > R_c
SUDS	60	-	ZDC[2] 60% 0-4 km; ZDC 15%, 4-8 km
FACT PL9D	60	1.0	
SUDS	65	-	ZDC 90%, 0-8.5 km; ZDC 50%, 11-12.5 km
FACT PL9D	65	2.0	
SUDS	70	9.0	ZDC 90%, 9.5-12.5 km; ZDC 5%, 14-17 km
FACT PL9D	70	3.0	
SUDS	75	9.0	ZDC 50%, 9-10 km; ZDC 90%, 10-13 km; ZDC 80%, 13-20 km
FACT PL9D	75	5.5	
SUDS	80	9.0	ZDC 90%, 9-21 km; ZDC 30%, 21-23.5 km; 100% coverage, 23.5-27.5 km
FACT PL9D	80	8.0	
SUDS	85	9.0	ZDC 90%, 9-32 km
FACT PL9D	85	12.0	
SUDS	90	23.0	ZDC 90%, 23-32 km; ZDC 10%, 32-36 km
FACT PL9D	90	15.0	
SUDS	95	23.0	ZDC 95%, 23-32.5 km; ZDC 50%, 32.5-36 km
FACT PL9D	95	19.0	

1. R_c = Range to which detection coverage is continuous.

2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval over which detection is possible.

CONFIDENTIAL

(C) Table IIA-11. Detection Range (km) as a Function of Figure of Merit (dB) for SUDS I Data and FACT PL9D Model Results.
CASE X:
(Station 1, Run 5, Source Depth = 45 m, Receiver Depth = 112 m, Frequency = 3.5 kHz)

DATA SET	FOM	R_c [1]	Range > R_c
SUDS	60	-	ZDC[2] 40%, 0-2.5 km
FACT PL9D	60	0.5	
SUDS	65	-	ZDC 80%, 0-3 km
FACT PL9D	65	1.5	
SUDS	70	-	ZDC 98%, 0-2.5 km; ZDC 15%, 2.5-4 km
FACT PL9D	70	3.0	
SUDS	75	2.5	ZDC 30%, 2.5-6 km
FACT PL9D	75	4.5	
SUDS	80	2.5	ZDC 60%, 4-6.5 km; ZDC 15%, 6.5-9 km
FACT PL9D	80	6.5	
SUDS	85	4.0	ZDC 85%, 4-6.5 km; ZDC 30%, 6.5-10.5 km
FACT PL9D	85	9.0	
SUDS	90	7.0	ZDC 60%, 7-12.5 km; ZDC ?%, 12.5-17 km (data clipped at 95 dB)
FACT PL9D	90	10.0	
SUDS	95	10.5	ZDC 90%, 10.5-12.5 km; ZDC = ?, 12.5-21 km (data clipped in this interval); ZDC 10%, 21-25 km
FACT PL9D	95	12.0	

1. R_c = Range to which detection coverage is continuous.
2. ZDC - Zonal Detection Coverage in percentage of the indicated range over which detection is possible.

CONFIDENTIAL

(C) Table IIA-12. Detection Range (km) as a Function of Figure of Merit (dB) for SUDS I Data and FACT PL9D Model Results.
CASE XI:
(Station 1, Run 6, Source Depth = 42 m, Receiver Depth = 17 m, Frequency = 5 kHz)

DATA SET	FOM	R_c[1]	Range > R_c
SUDS	70	-	ZDC[2] 50%, 0-2 km
FACT PL9D	70	2.5	
SUDS	75	-	ZDC 60%, 0-2 km; ZDC 15%, 2.4 km; ZDC 60%, 5.5-6.5 km
FACT PL9D	75	5.0	
SUDS	80	1.5	ZDC 80%, 1.5-5 km; ZDC 60%,5-8.5 km
FACT PL9D	80	7.0	
SUDS	85	1.5	ZDC 90%, 1.5-7 km; ZDC 70%, 7-13.5 km; ZDC 15%, 13.5-19 km
FACT PL9D	85	9.5	
SUDS	90	4.5	ZDC 85%, 4.5-13 km; ZDC 50%, 13-19 km
FACT PL9D	90	12.5	
SUDS	95	5.0	ZDC 90%, 5-19 km; ZDC 10%, 19-27 km
FACT PL9D	95	15.5	
SUDS	100	10.5	ZDC 95%, 10.5-19.5 km; ZDC 60%, 19.5-27.5 km; ZDC 15%, 27.5-32 km
FACT PL9D	100	19.0	
SUDS	105	19.5	ZDC 90%, 19.5-32 km
FACT PL9D	105	21.5	
SUDS	110	23.0	ZDC 95%, 23-32 km; ZDC 10%, 32-35.5 km
FACT PL9D	110	24.5	

1. R_c = Range to which detection coverage is continuous.

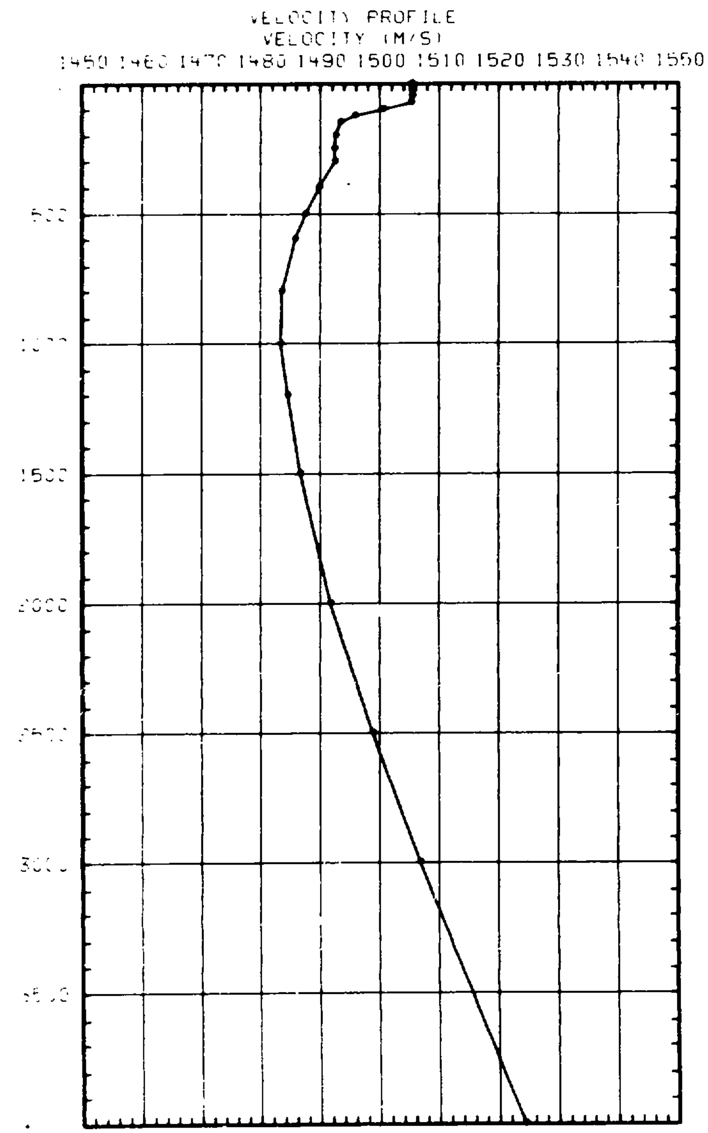
2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval over which detection is possible.

CONFIDENTIAL

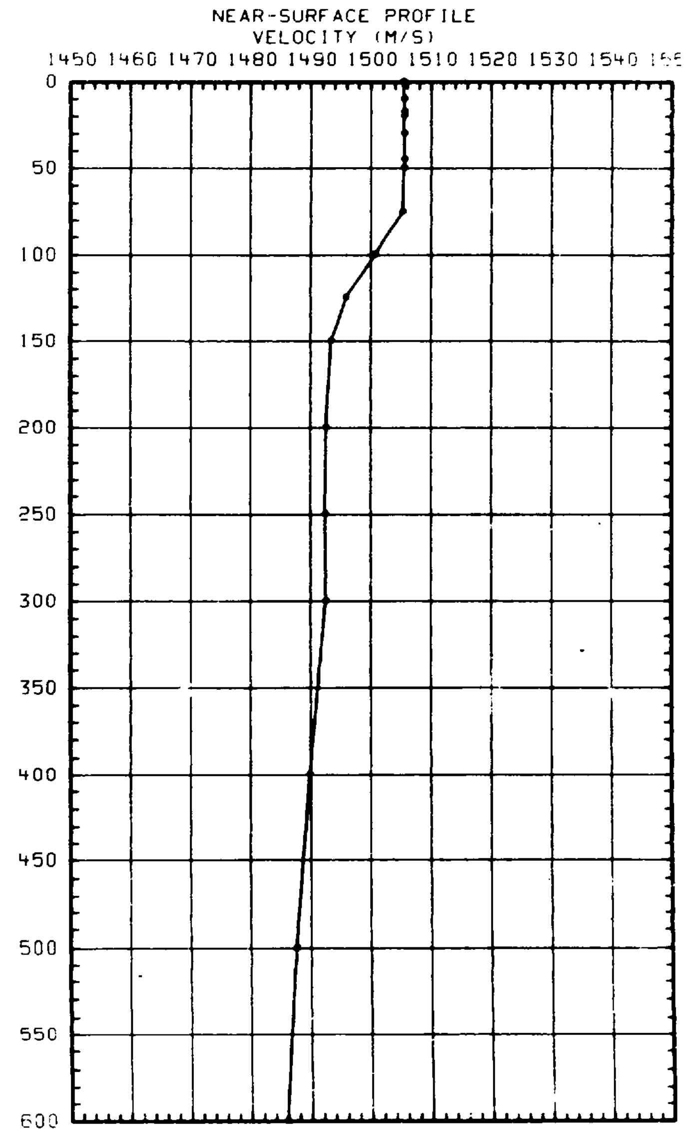
(C) Table IIA-13. Detection Range (km) as a Function of
Figure of Merit (dB) for SUDS I Data and
FACT PL9D Model Results.
CASE XII:
(Station 1, Run 6, Source Depth = 42 m, Receiver Depth = 112 m,
Frequency = 5 kHz)

DATA SET	FOM	R_c [1]	Range > R_c
SUDS	65	0.5	
FACT PL9D	65	1.5	
SUDS	70	0.5	ZDC[2] 50%, 0.5-1.5 km
FACT PL9D	70	2.5	
SUDS	75	2.5	ZDC 50%, 0.5-2.0 km
FACT PL9D	75	4.5	
SUDS	80	1.0	ZDC 50%,1-2 km; ZDC 15%, 2-3.5 km
FACT PL9D	80	6.0	
SUDS	85	1.0	ZDC 90%, 1-3 km; ZDC 30%, 3-4 km
FACT PL9D	85	8.0	
SUDS	90	2.5	ZDC 30%, 2.5-5.5 km
FACT PL9D	90	9.5	
SUDS	95	3.5	ZDC 30%, 3.5-7.0 km
FACT PL9D	95	10.5	
SUDS	100	4.0	ZDC ?%, 4-14 km (data is clipped at high loss end)
FACT PL9D	100	12.5	
SUDS	105	5.0	ZDC ?%, 5-16.5 km (data is clipped at high loss end)
FACT PL9D	105	15.0	
SUDS	110	7.0	ZDC ?%, 7-25 km (data is clipped at high loss end)
FACT PL9D	110	18.5	

1. R_c = Range to which detection coverage is continuous.
2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval over which detection is possible.

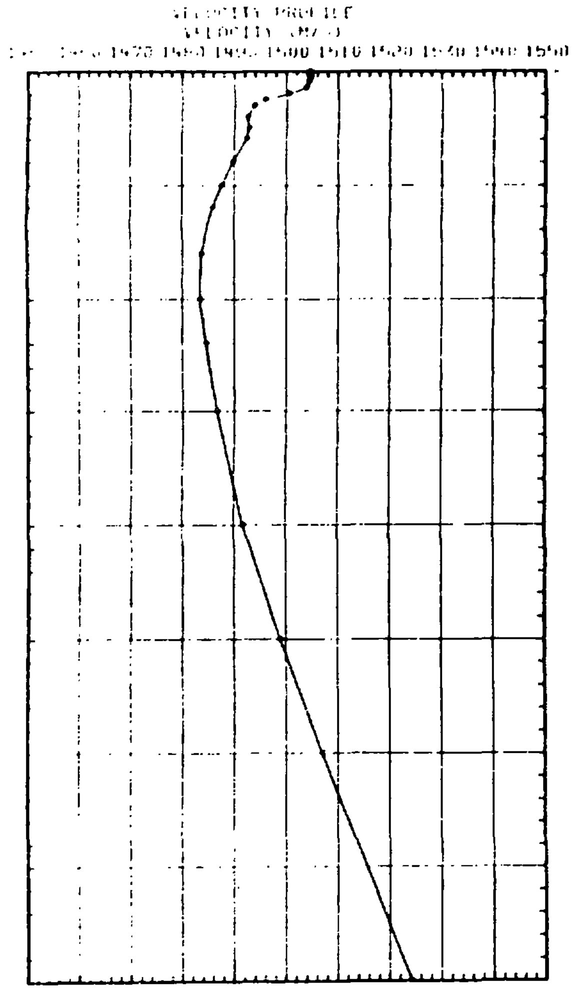


DEPTH	VELOCITY
0.0	1505.29
10.0	1505.41
17.4	1505.43
20.0	1505.44
30.0	1505.46
45.0	1505.47
50.0	1505.47
75.0	1505.25
100.0	1500.61
125.0	1495.80
150.0	1493.38
200.0	1492.48
250.0	1492.37
300.0	1492.45
400.0	1489.79
500.0	1487.54
600.0	1485.79
800.0	1483.59
1000.0	1483.39
1200.0	1484.57
1500.0	1486.66
2000.0	1491.70
2500.0	1498.90
3000.0	1506.90
4000.0	1524.30

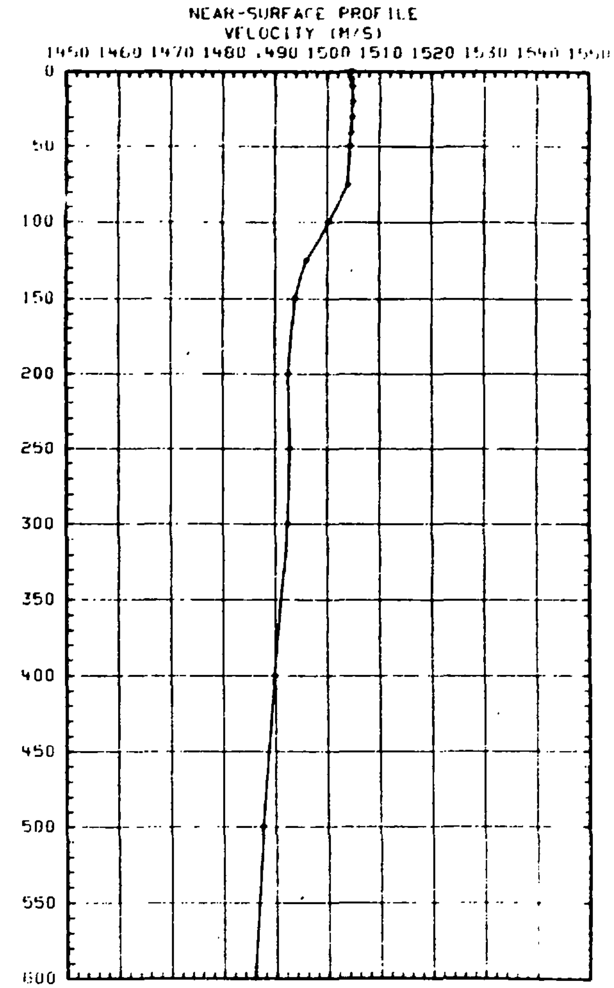


CONFIDENTIAL

(U) Figure IIA-1. SUDS Sound Speed Profile A

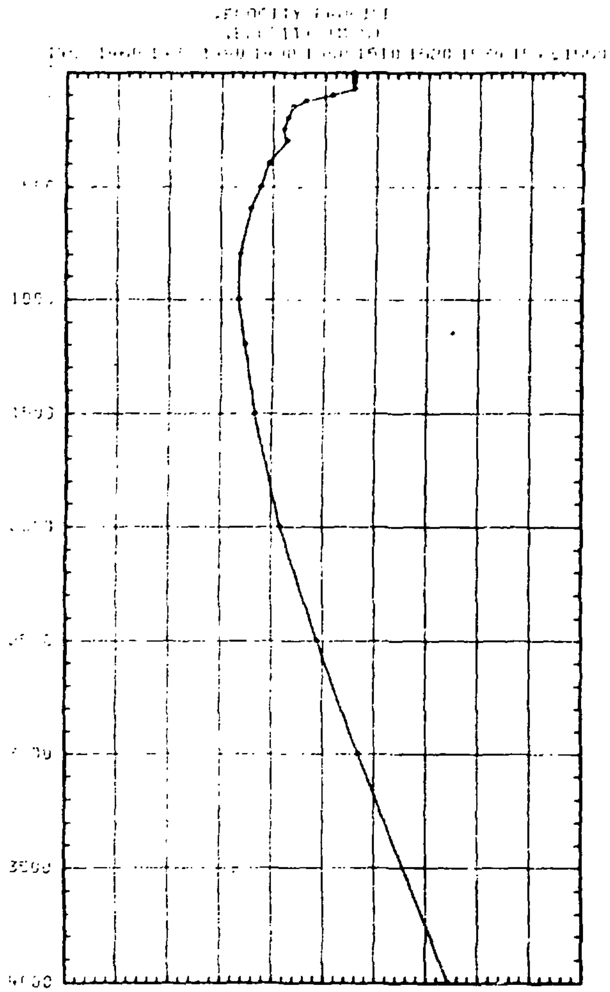


DEPTH	VELOCITY
0.0	1504.51
5.0	1504.[illegible]
10.0	1504.[illegible]
20.0	1504.67
30.0	1504.61
41.0	1504.43
50.0	1504.[illegible]
75.0	1503.77
100.0	1500.33
125.0	1495.80
150.0	1493.73
200.0	1492.41
250.0	1492.71
300.0	1492.33
400.0	1489.69
500.0	1487.54
600.0	1485.79
800.0	1483.59
1000.0	1483.39
1200.0	1484.57
1500.0	1486.66
2000.0	1491.70
2500.0	1498.90
3000.0	1506.90
4000.0	1524.30

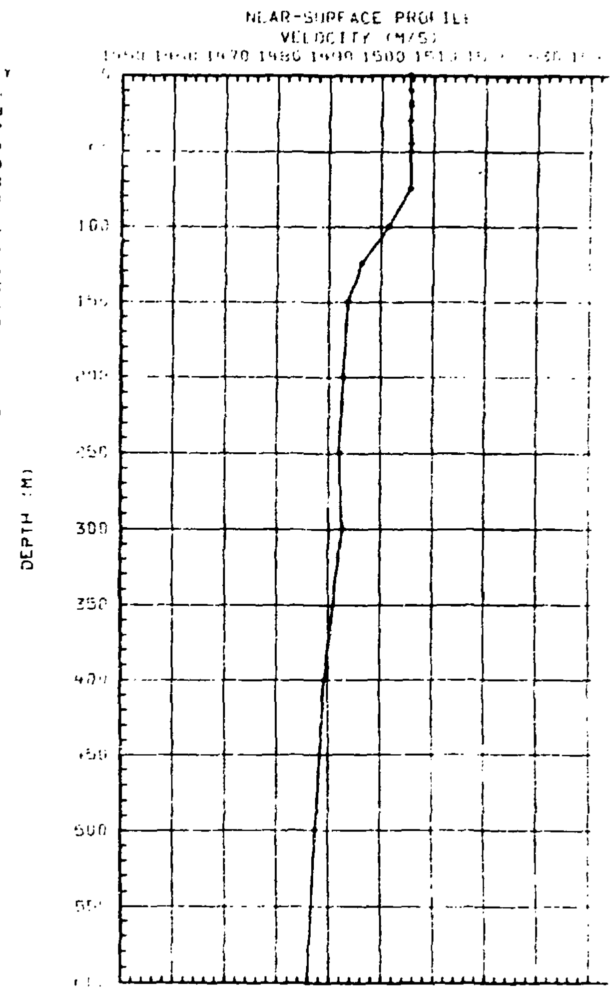


CONFIDENTIAL

(U) Figure IIA-2. SUDS Sound Speed Profile E.

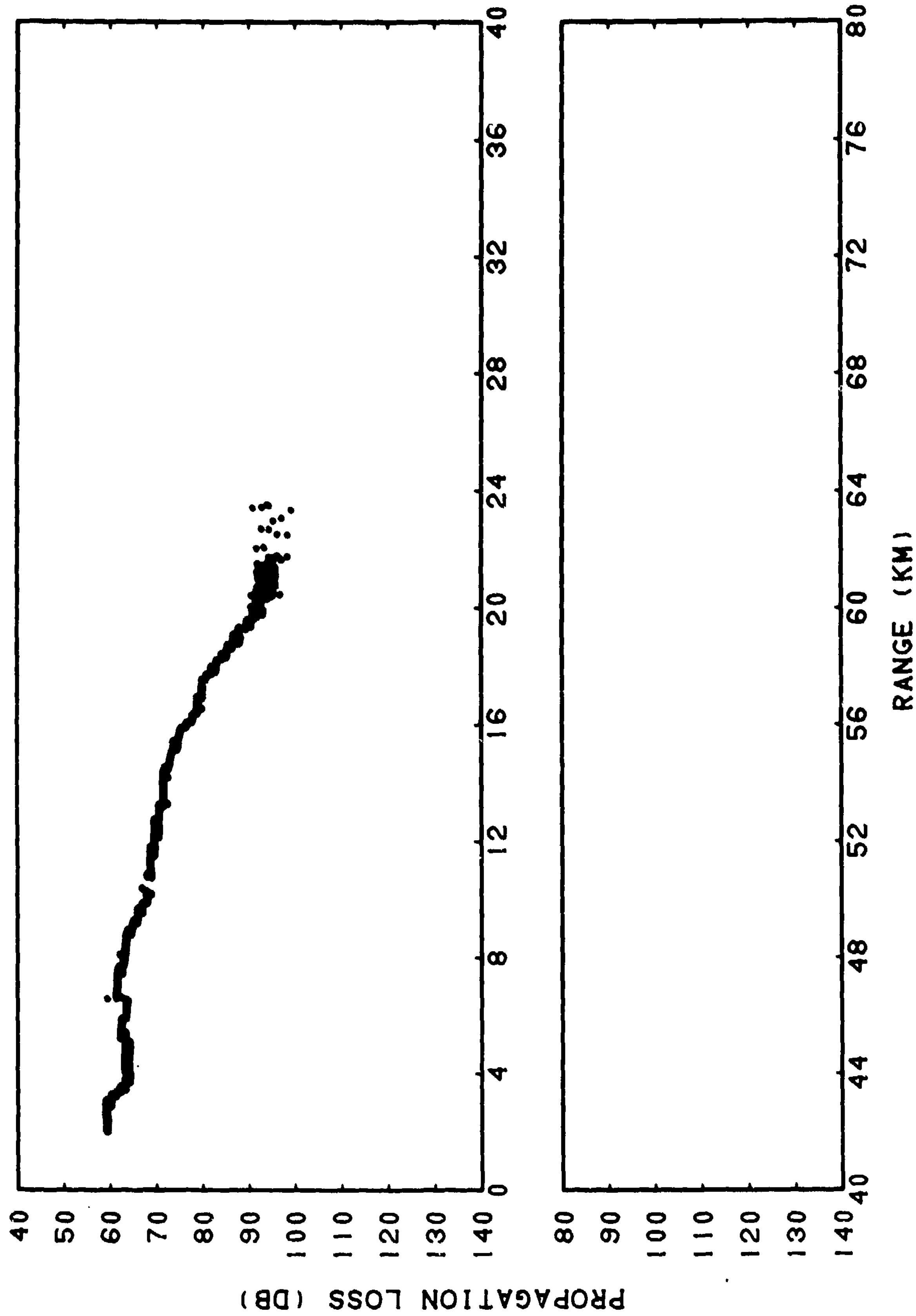


DEPTH	VELOCITY
0.0	[illegible]
10.0	[illegible]
[illegible]	[illegible]
20.0	[illegible]
30.0	[illegible]
45.0	[illegible]
50.0	[illegible]
75.0	[illegible]
100.0	1501.37
[illegible]	[illegible]
150.0	1493.66
[illegible]	[illegible]
[illegible]	[illegible]
300.0	1492.59
400.0	1483.20
500.0	1487.54
600.0	1485.79
800.0	1483.59
1000.0	1483.39
1200.0	1484.57
1500.0	1486.66
2000.0	1491.70
2500.0	1498.90
3000.0	1506.90
4000.0	1524.30



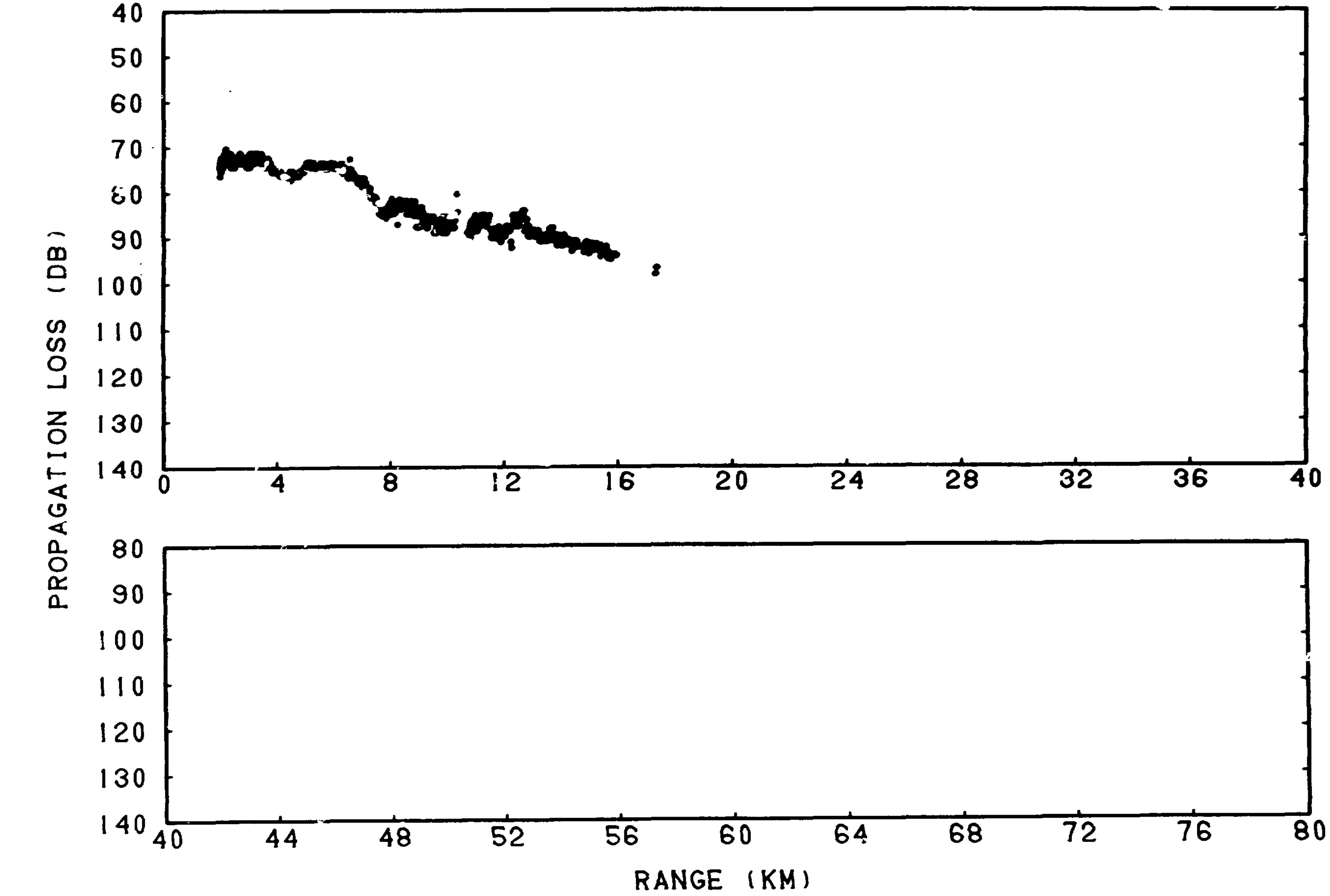
CONFIDENTIAL

(U) Figure IIA-3. SUDS Sound Speed Profile B.



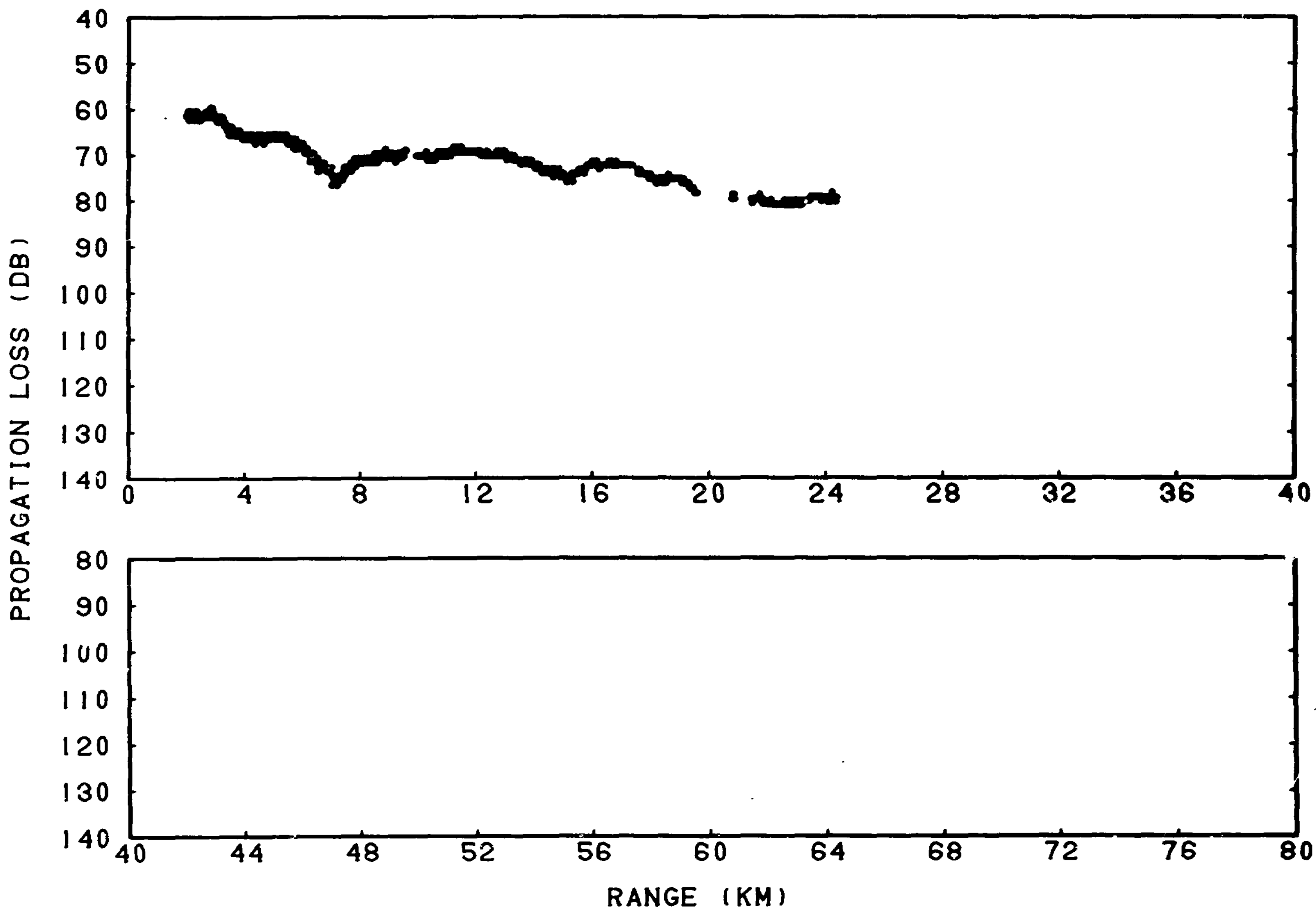
CONFIDENTIAL

(C) Figure IIA-4. SUDS Data, Frequency = 0.4 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 17 Meters



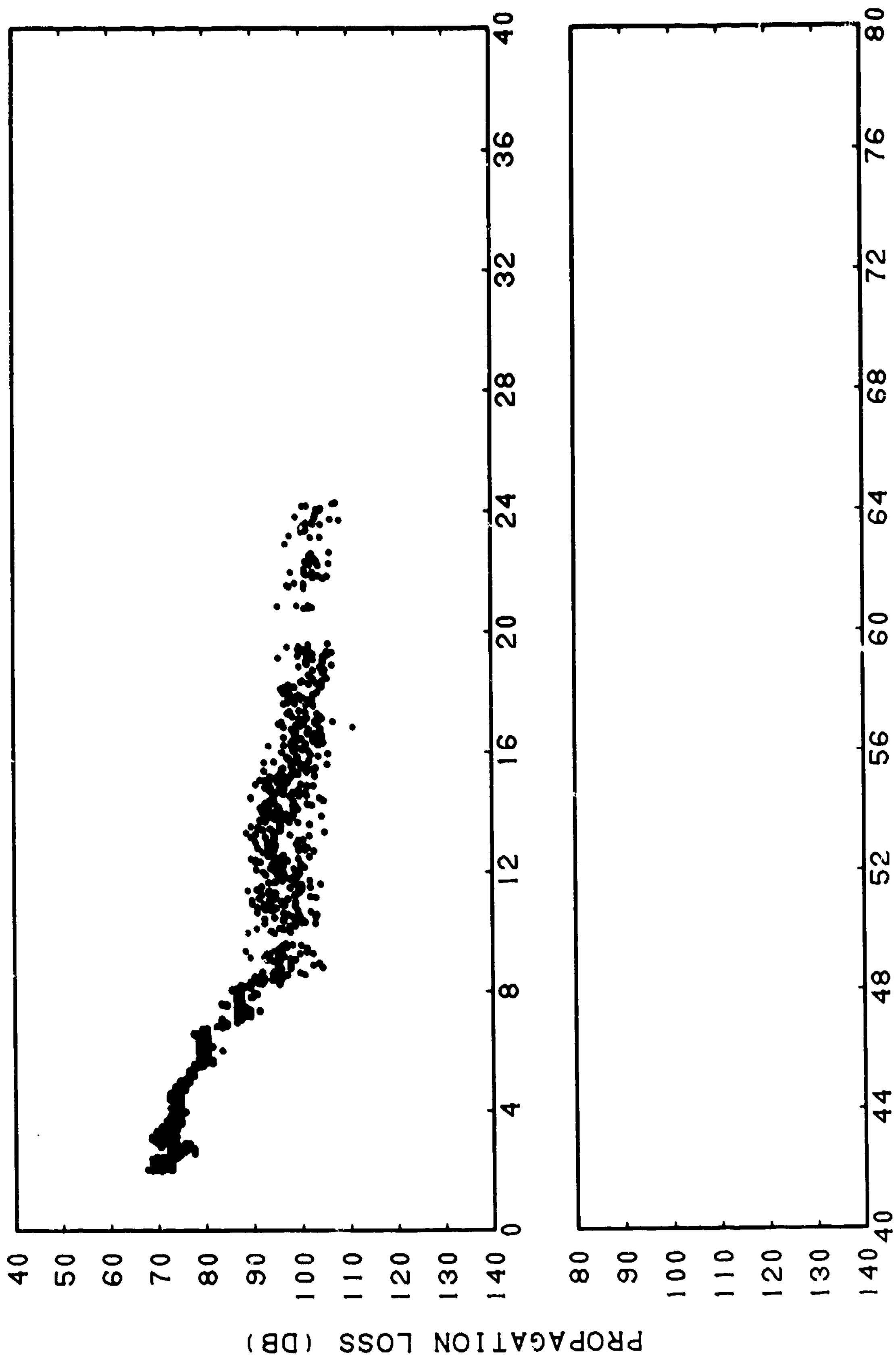
CONFIDENTIAL

(C) Figure IIA-5. SUDS Data, Frequency = 0.4 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 112 Meters



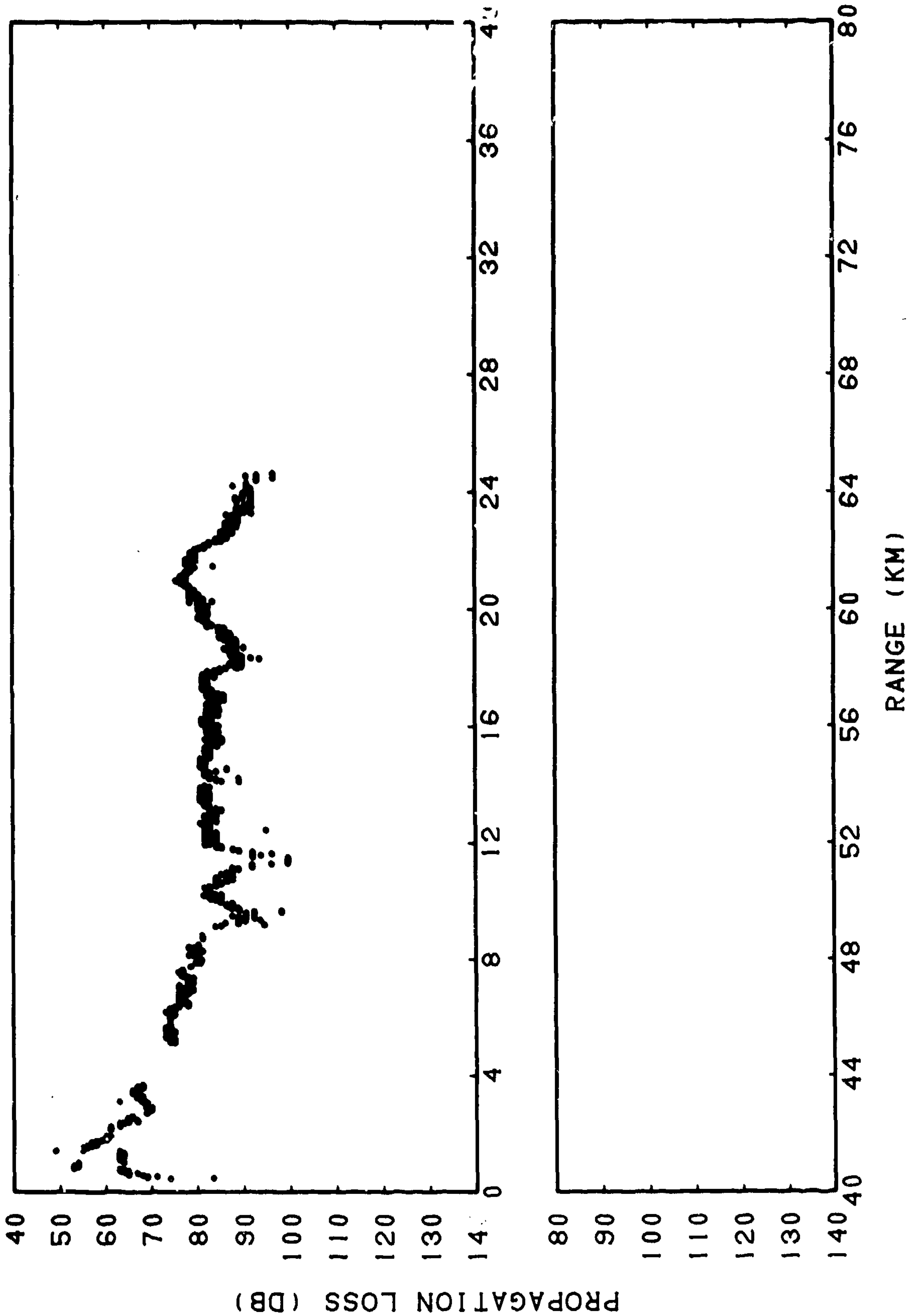
CONFIDENTIAL

(C) Figure IIA-6. SUDS Data, Frequency = 1.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 43 Meters



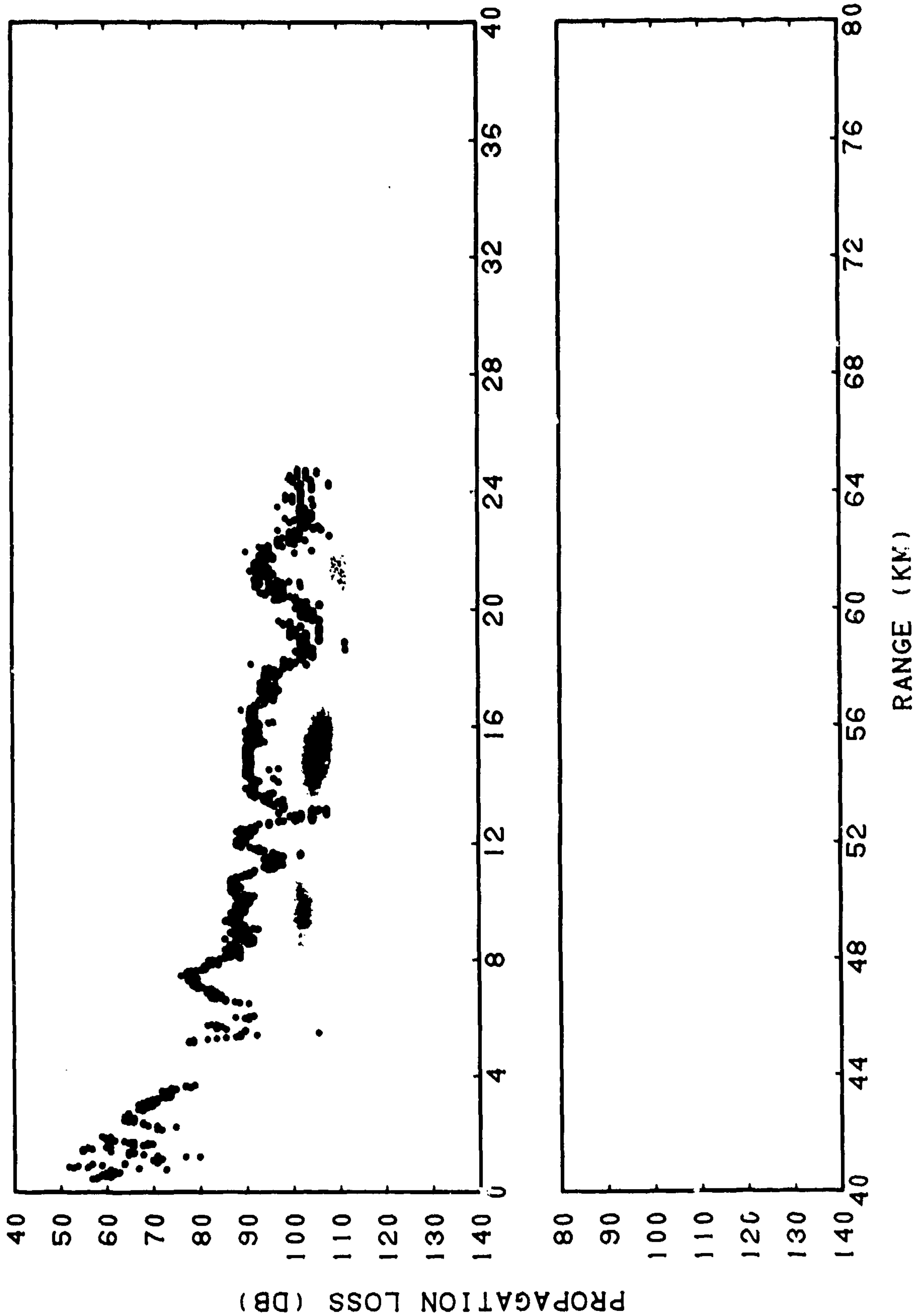
CONFIDENTIAL

(C) Figure IIA-7. SUDS Data, Frequency = 1.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 112 Meters



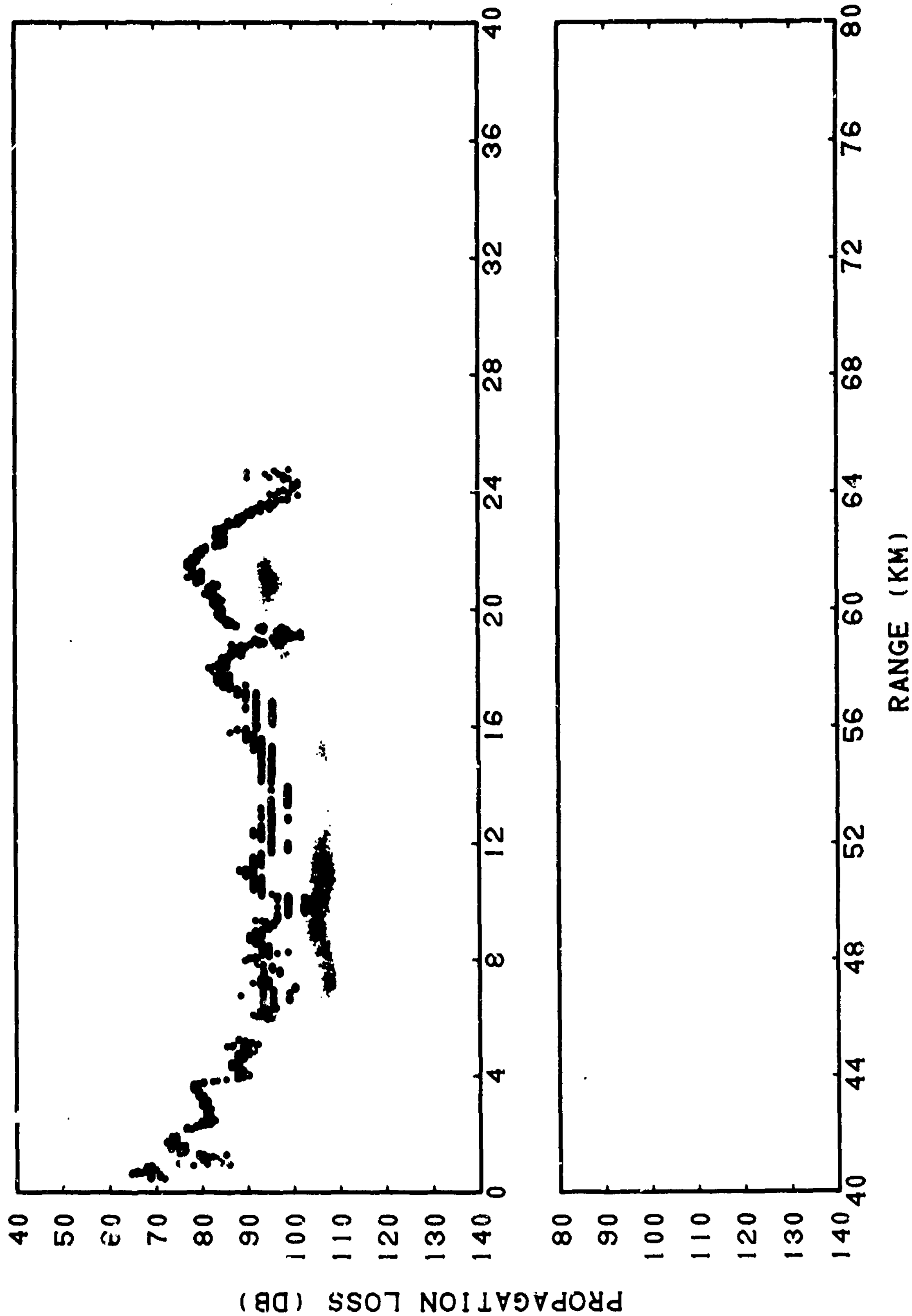
CONFIDENTIAL

(C) Figure IIA-8. SUDS Data, Frequency = 1.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 6 Meters



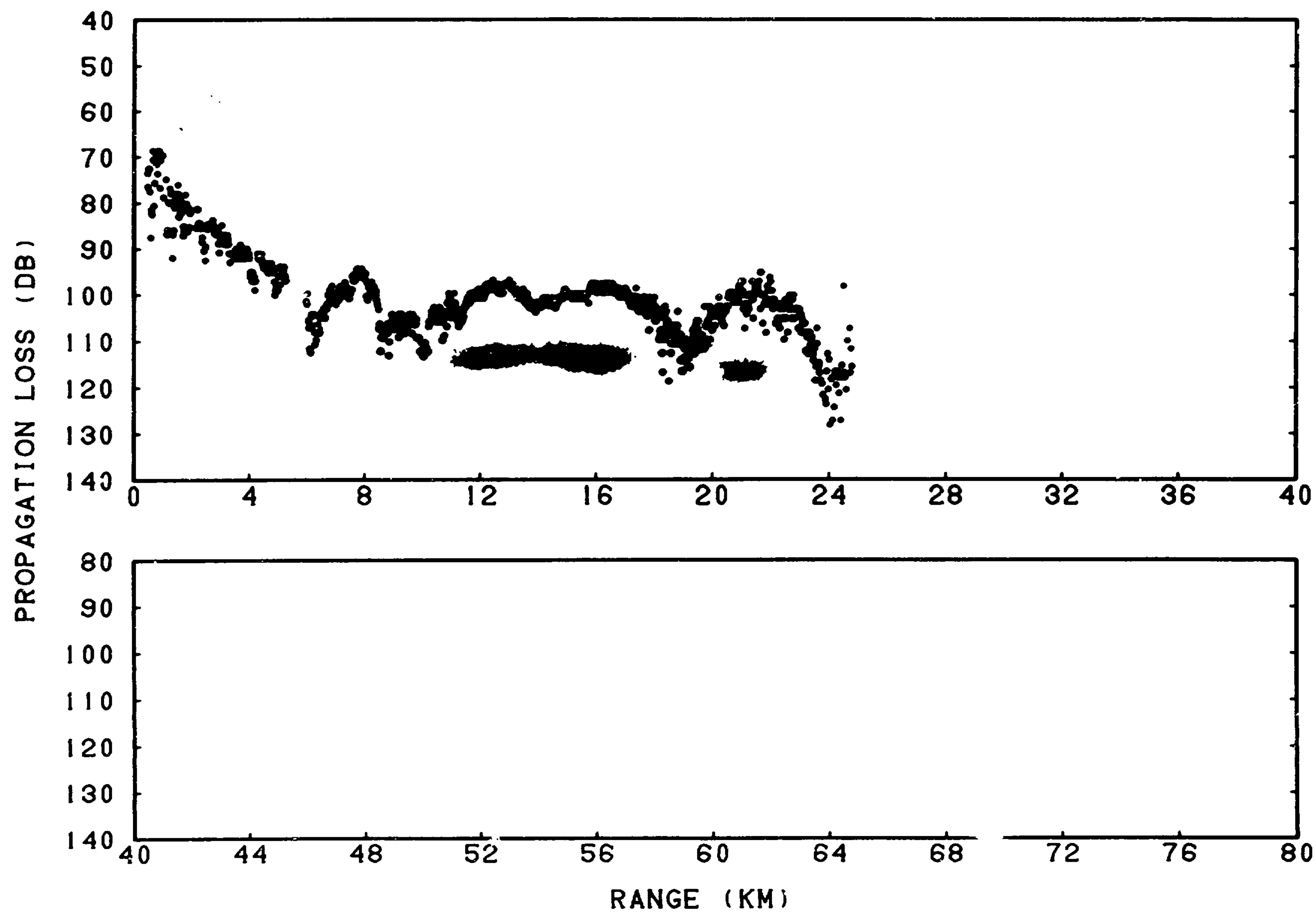
CONFIDENTIAL

(C) Figure IIA-9. SUDS Data, Frequency = 1.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 59 Meters



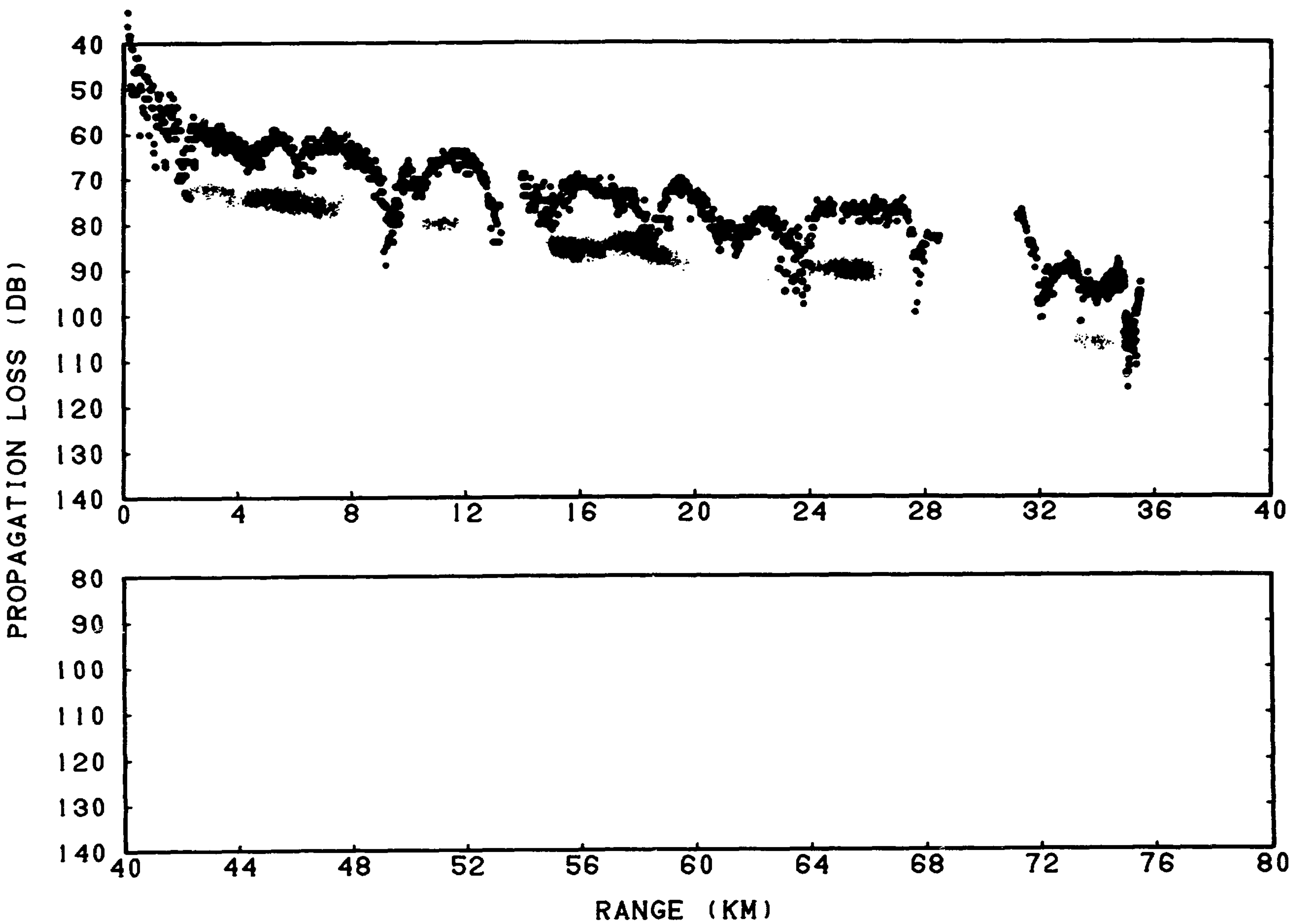
CONFIDENTIAL

(C) Figure IIA-10. SUDS Data, Frequency = 2.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 6 Meters



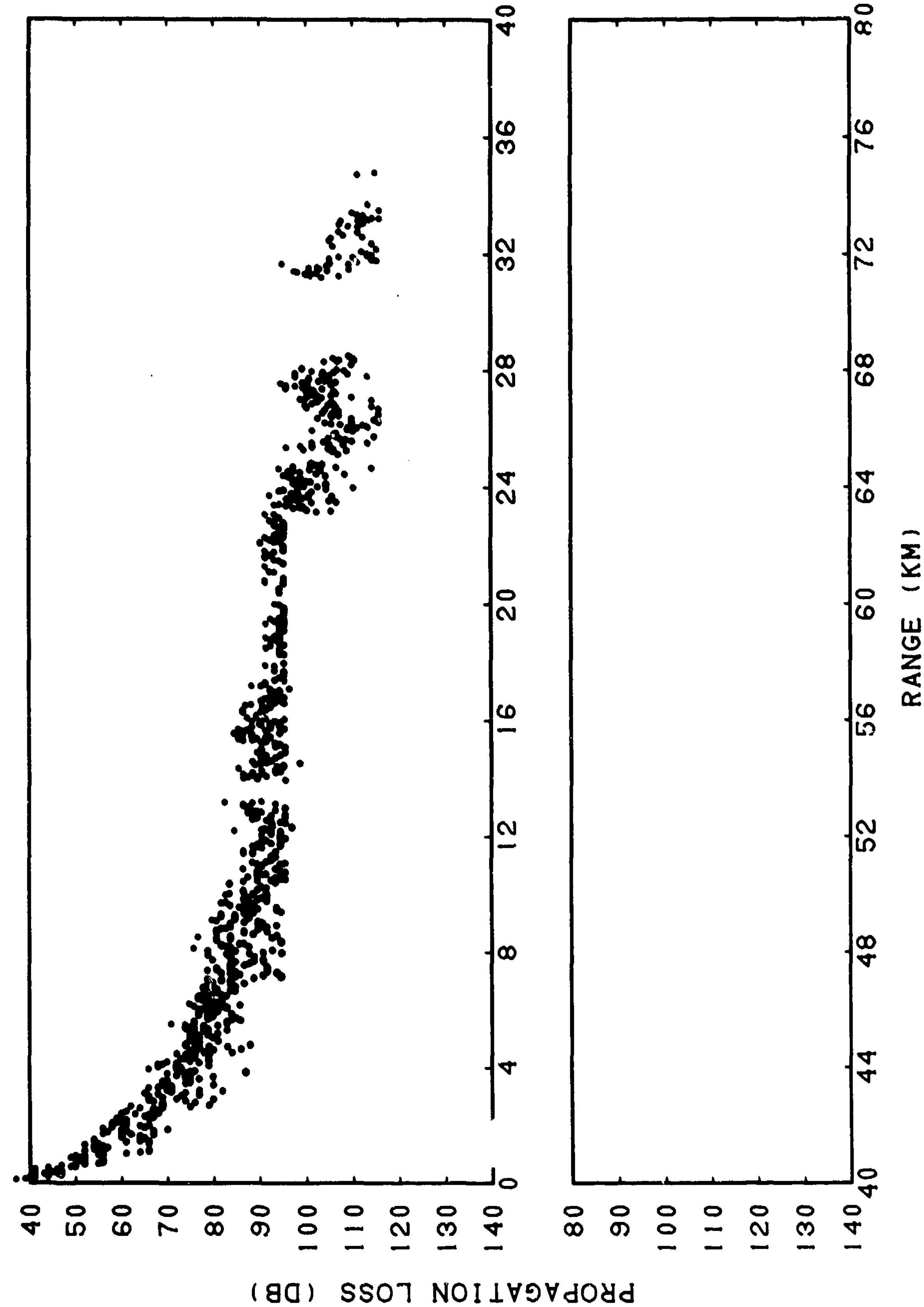
CONFIDENTIAL

(C) Figure IIA-11. SUDS Data, Frequency = 2.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 59 Meters



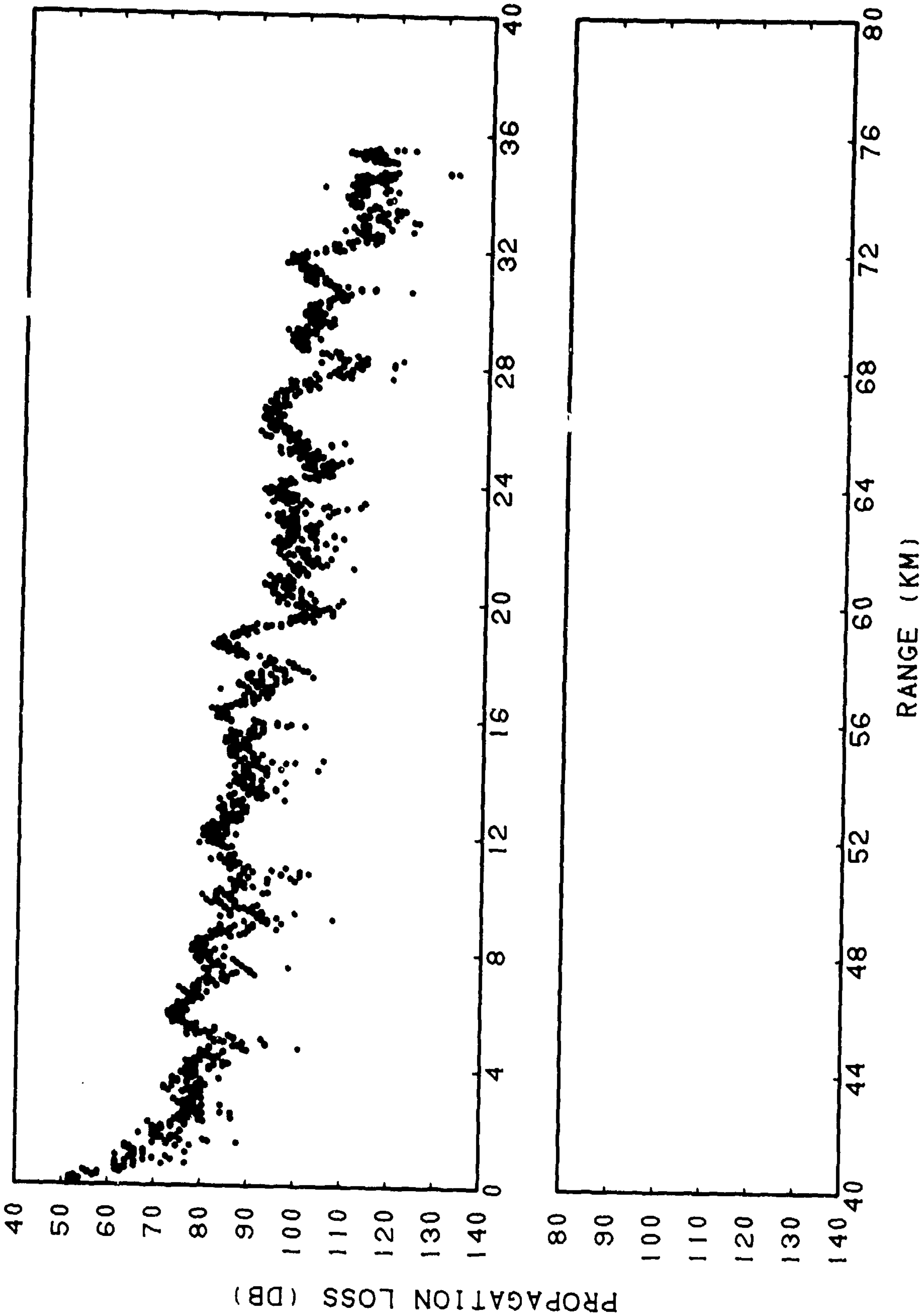
CONFIDENTIAL

(C) Figure IIA-12. SUDS Data, Frequency = 3.5 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 17 Meters



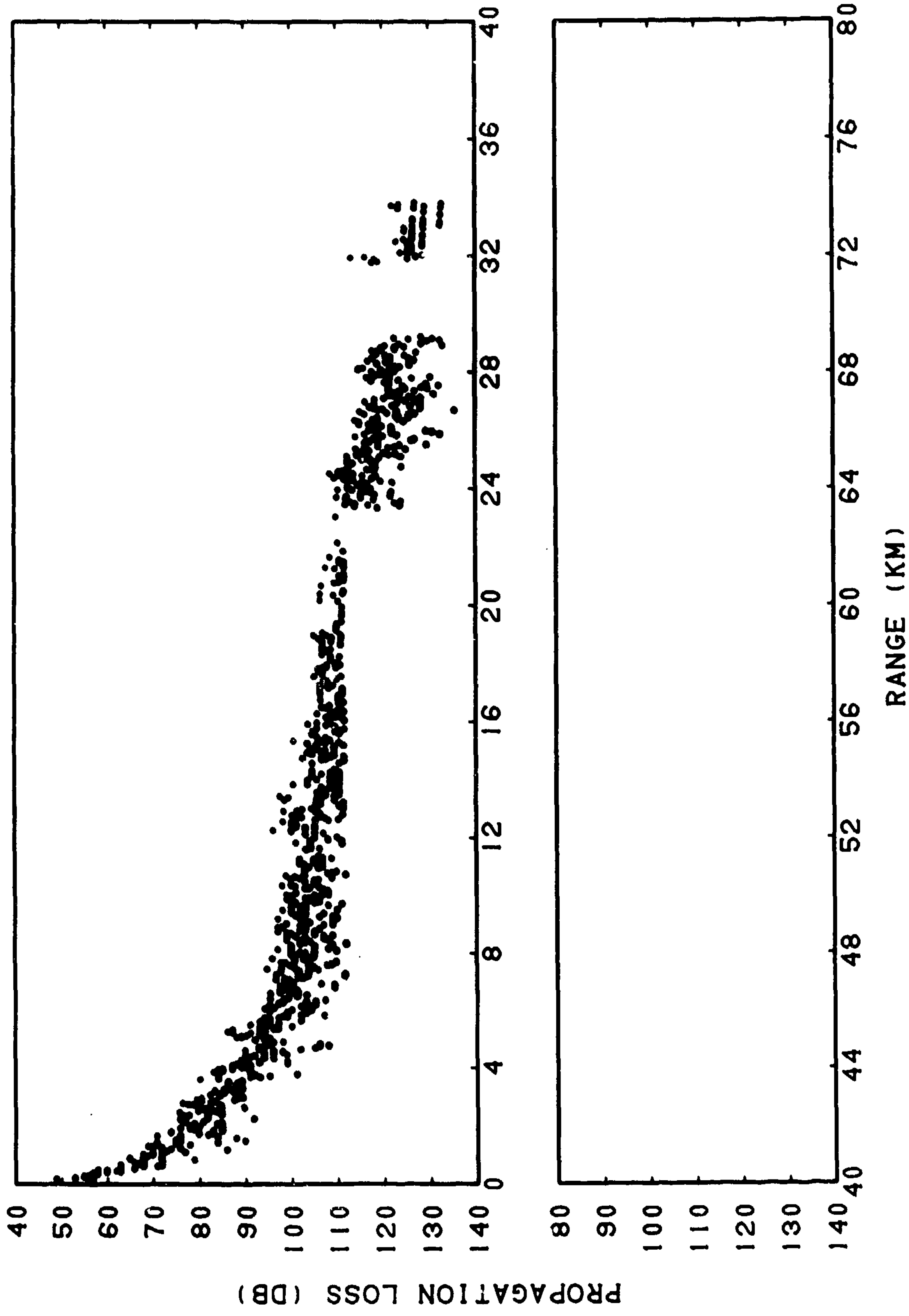
CONFIDENTIAL

(C) Figure IIA-13. SUDS Data, Frequency = 3.5 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 112 Meters



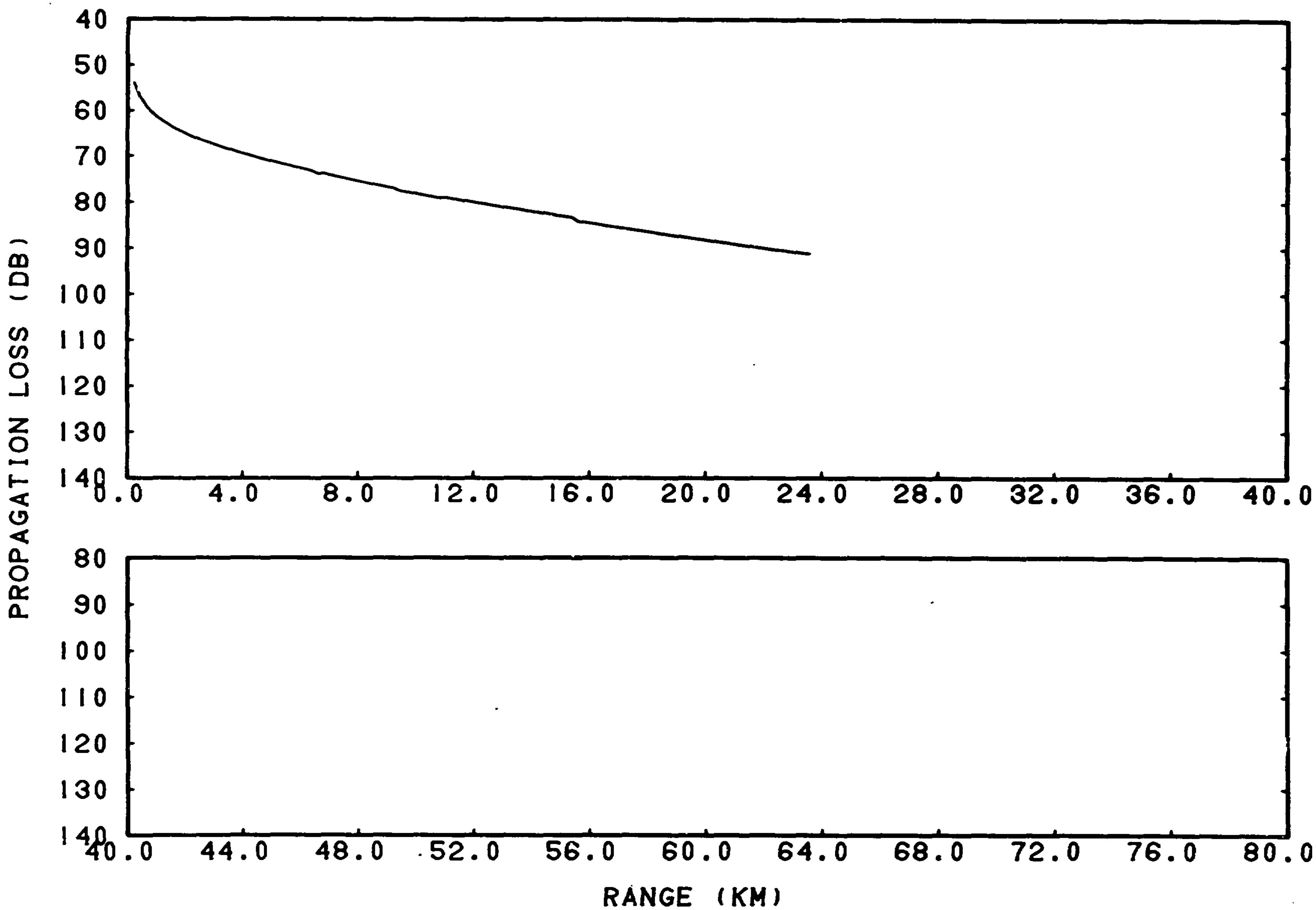
CONFIDENTIAL

(C) Figure IIA-14. SUDS Data, Frequency = 5.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 17 Meters



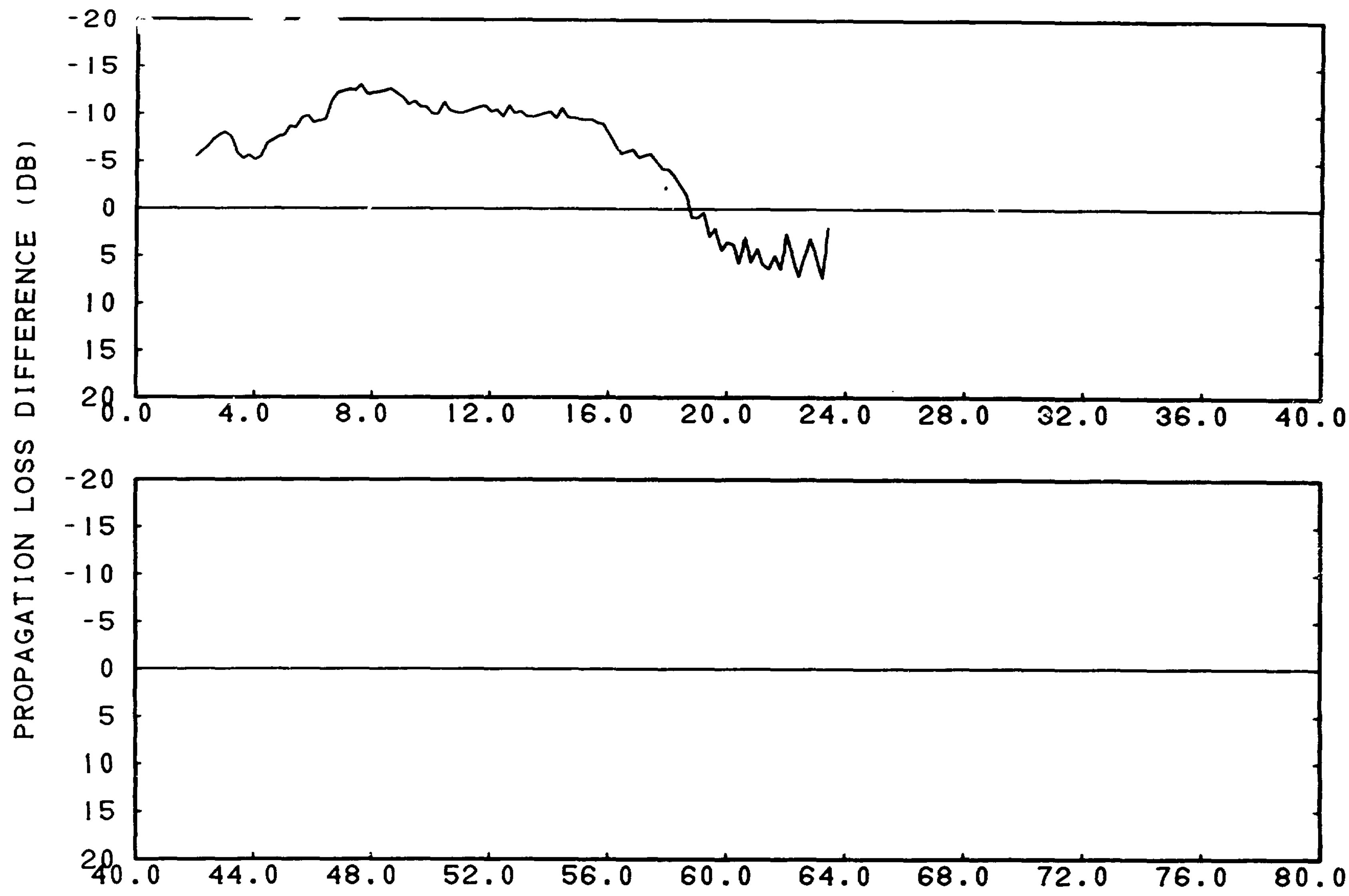
CONFIDENTIAL

(C) Figure IIA-15. SUDS Data, Frequency = 5.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 112 Meters



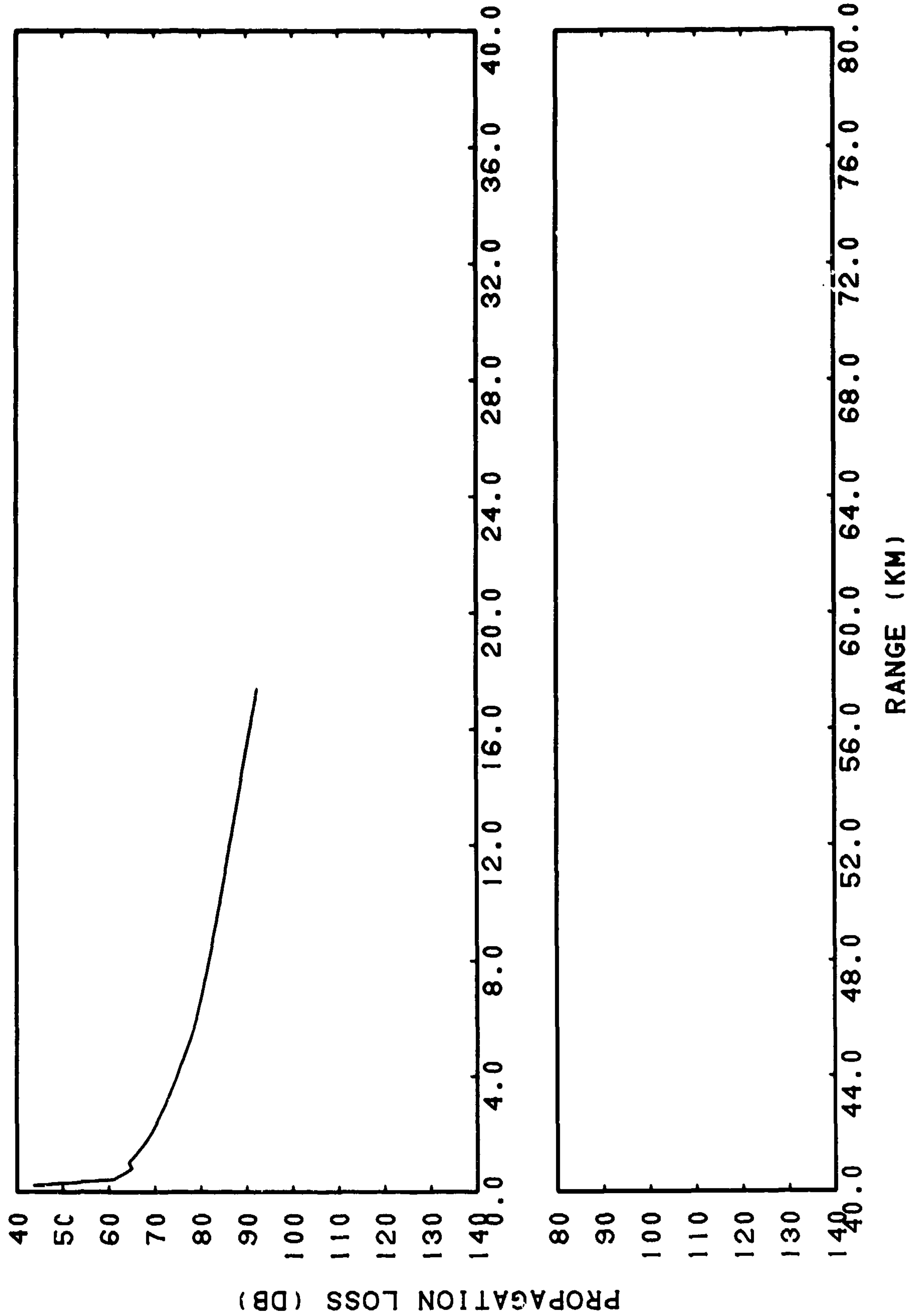
CONFIDENTIAL

(C) Figure IIA-16. FACT Semi-coherent, Frequency = 0.4 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 17 Meters



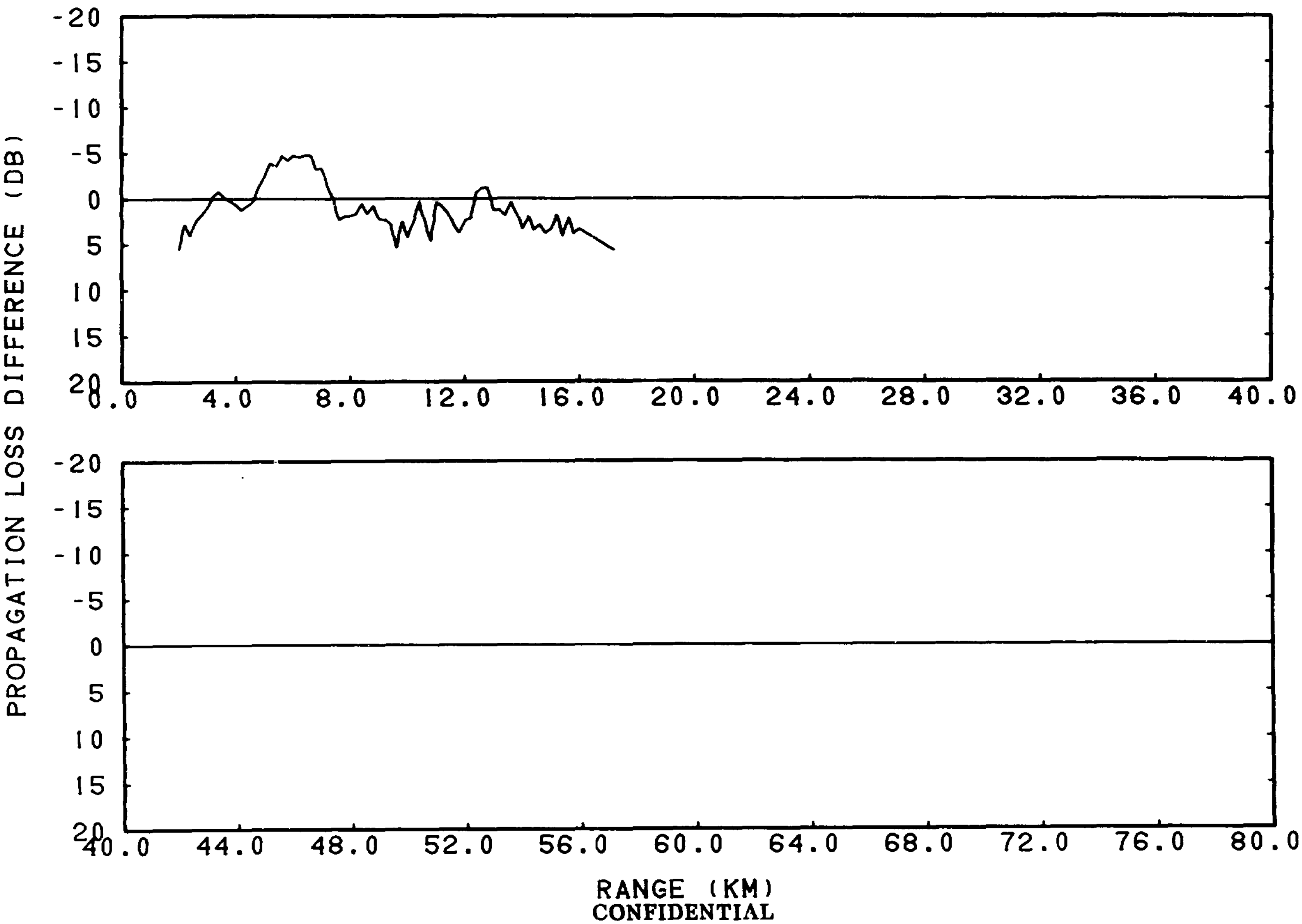
CONFIDENTIAL

(C) Figure IIA-17. FACT Semi-coherent, Frequency = 0.4 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 17 Meters Subtracted from SUDS Data, Frequency = 0.4 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 17 Meters



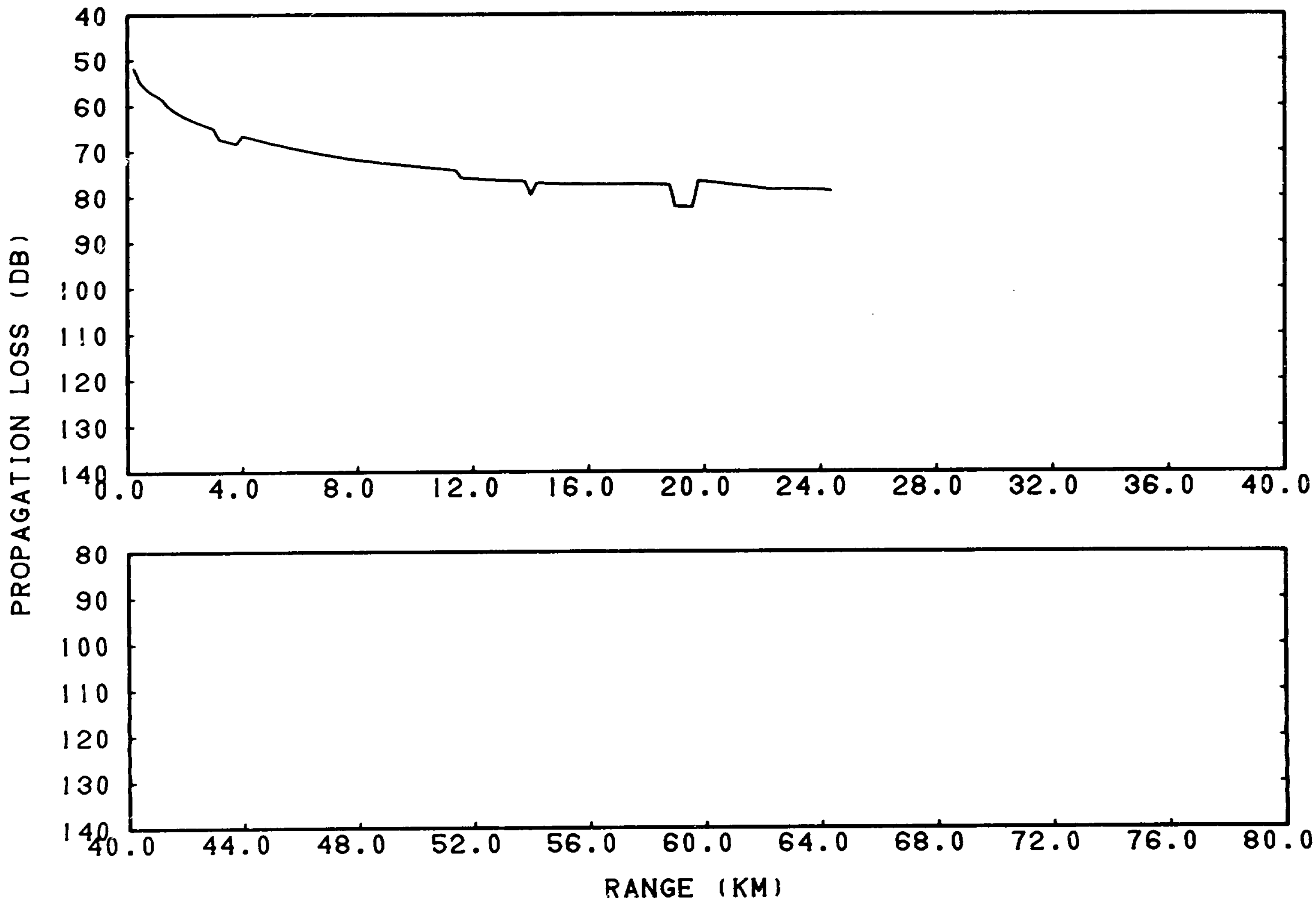
CONFIDENTIAL

(C) Figure IIA-18. FACT Semi-coherent, Frequency = 0.4 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 112 Meters



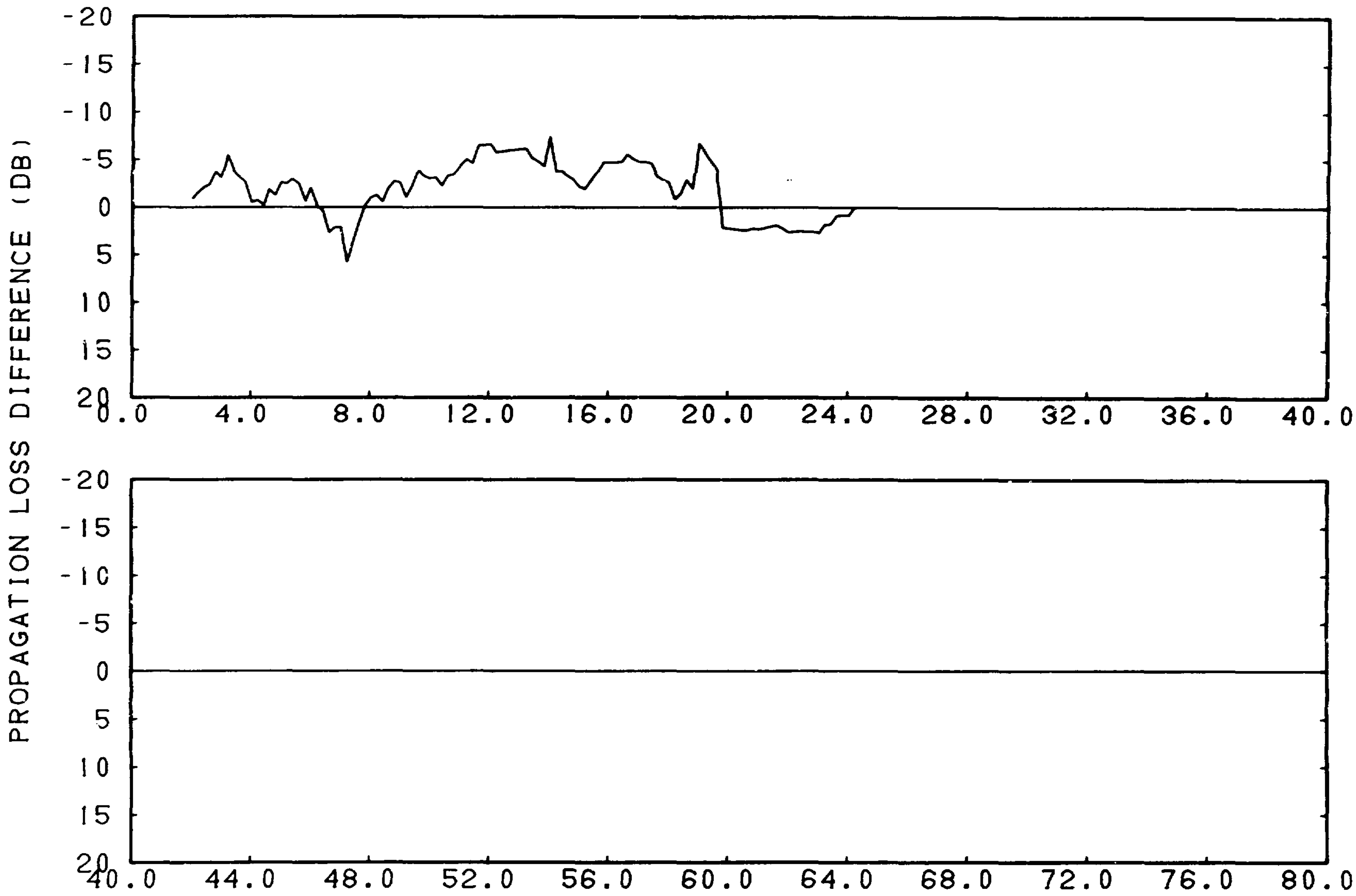
CONFIDENTIAL

(C) Figure IIA-19. FACT Semi-coherent, Frequency = 0.4 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 112 Meters Subtracted from SUDS Data, Frequency = 0.4 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 112 Meters



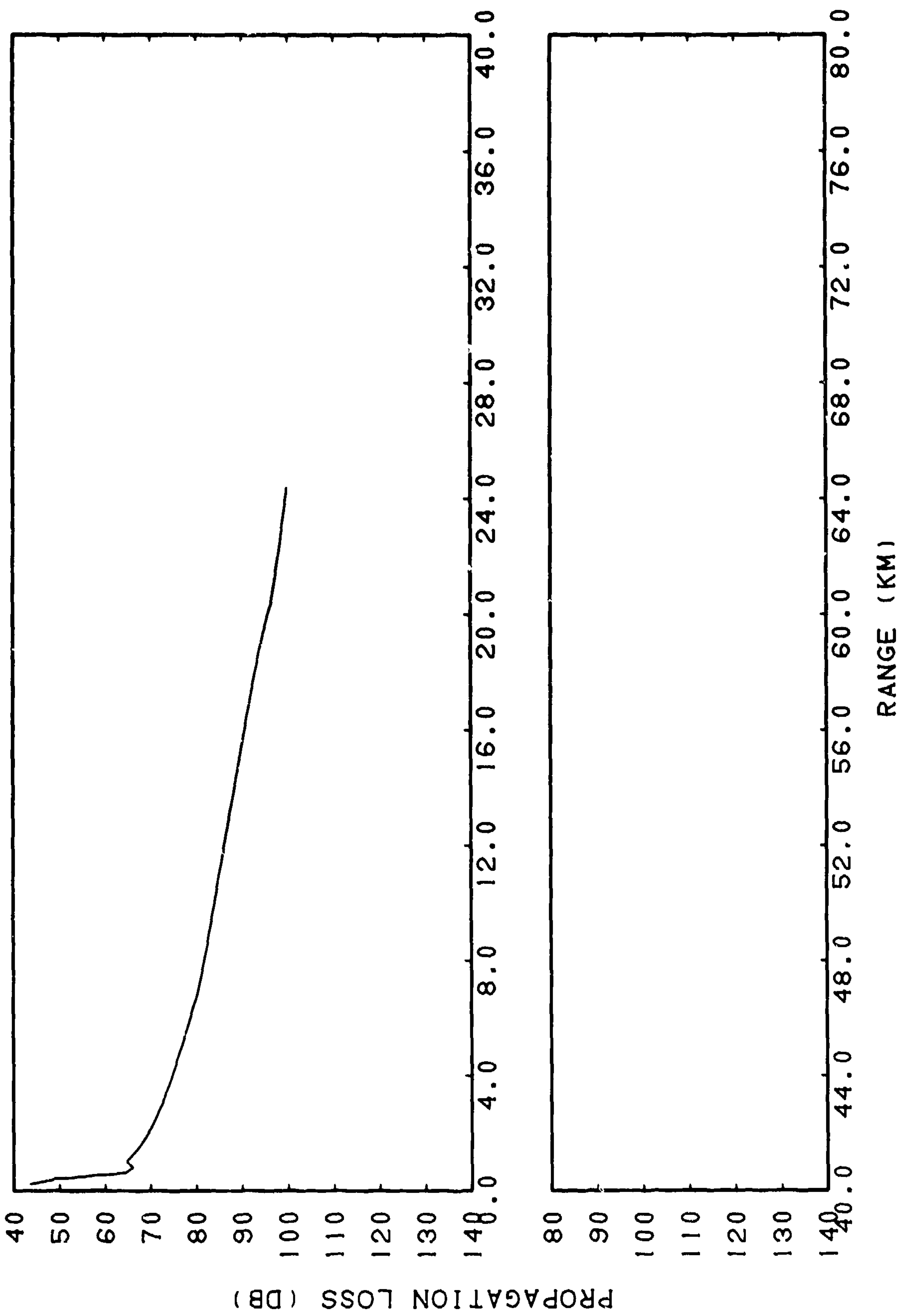
CONFIDENTIAL

(C) Figure IIA-20. FACT Semi-coherent, Frequency = 1.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 43 Meters



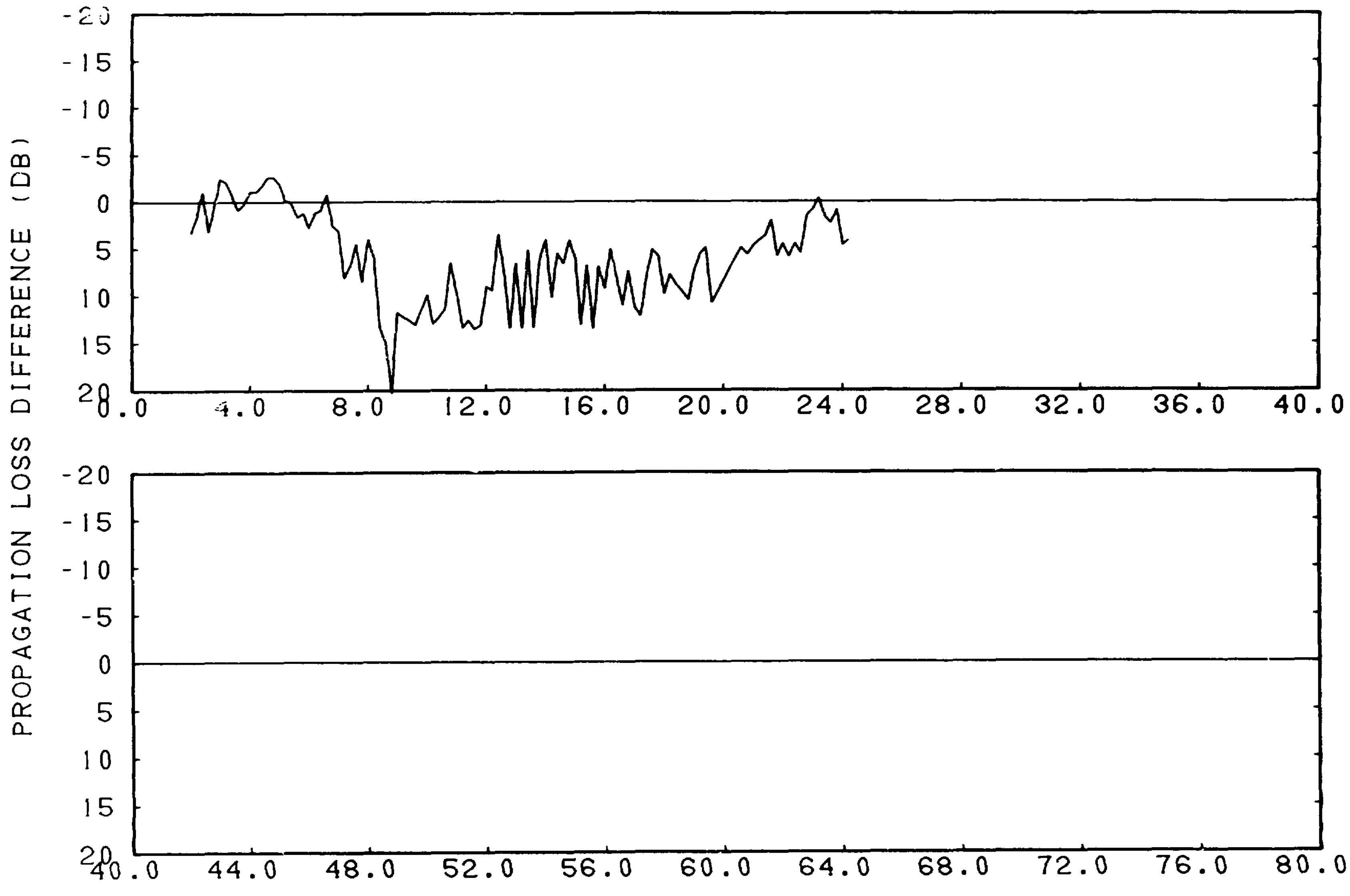
CONFIDENTIAL

(C) Figure IIA-21. FACT Semi-coherent, Frequency = 1.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 43 Meters Subtracted from SUDS Data, Frequency = 1.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 43 Meters



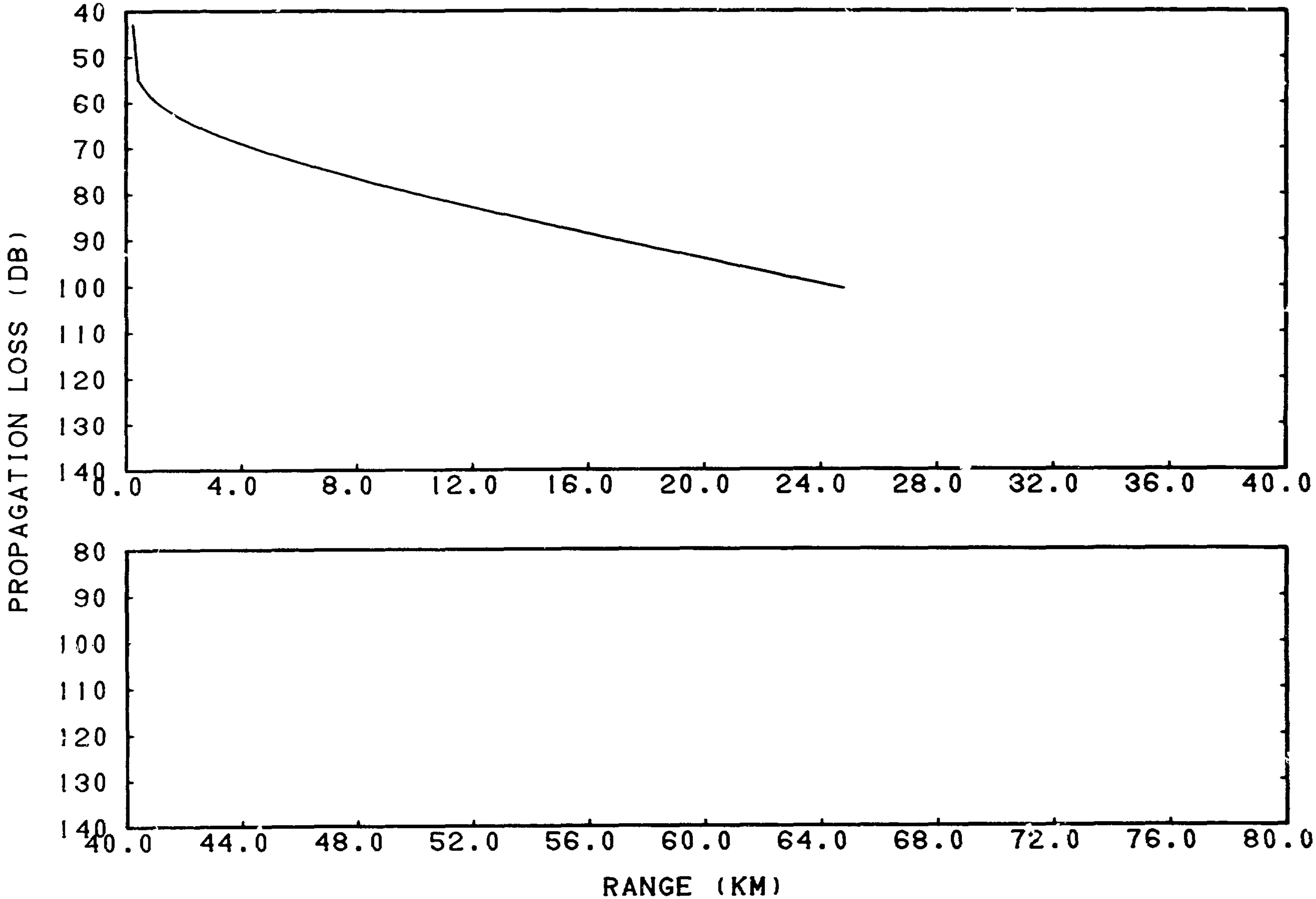
CONFIDENTIAL

(C) Figure IIA-22. FACT Semi-coherent, Frequency = 1.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 112 Meters



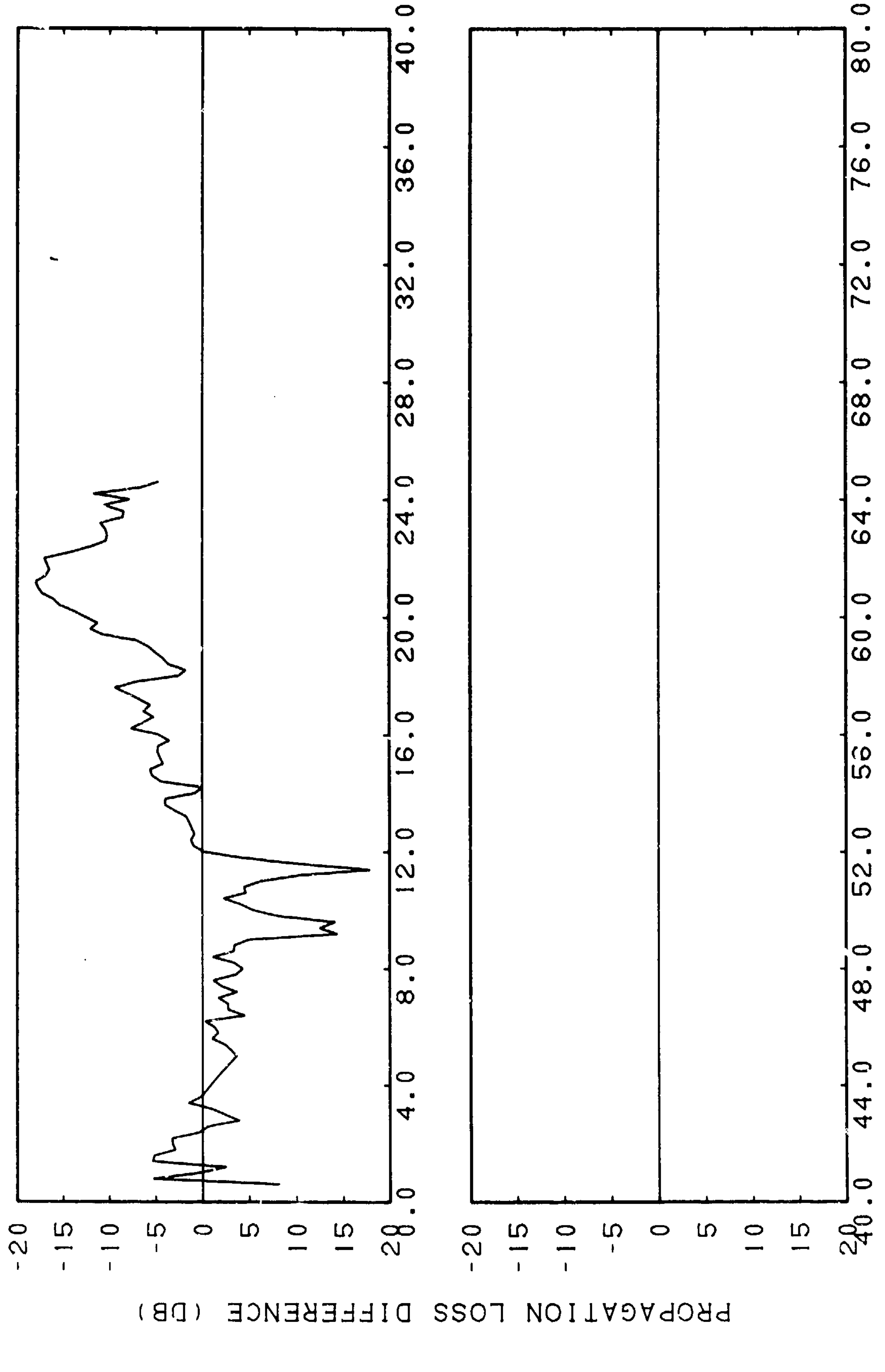
CONFIDENTIAL

(C) Figure IIA-23. FACT Semi-coherent, Frequency = 1.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 112 Meters Subtracted from SUDS Data, Frequency = 1.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 112 Meters

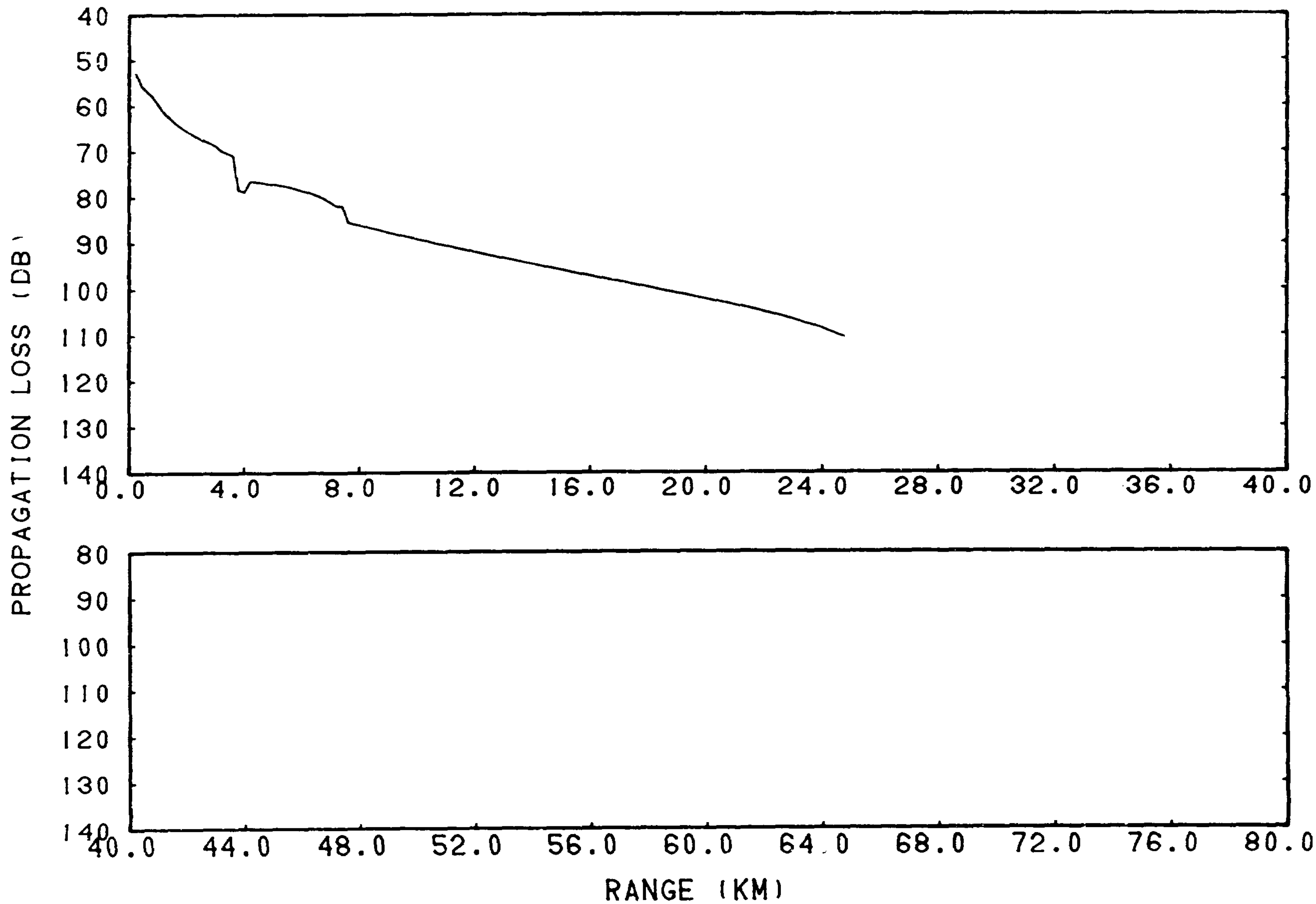


CONFIDENTIAL

(C) Figure IIA-24. FACT Semi-coherent, Frequency = 1.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 6 Meters

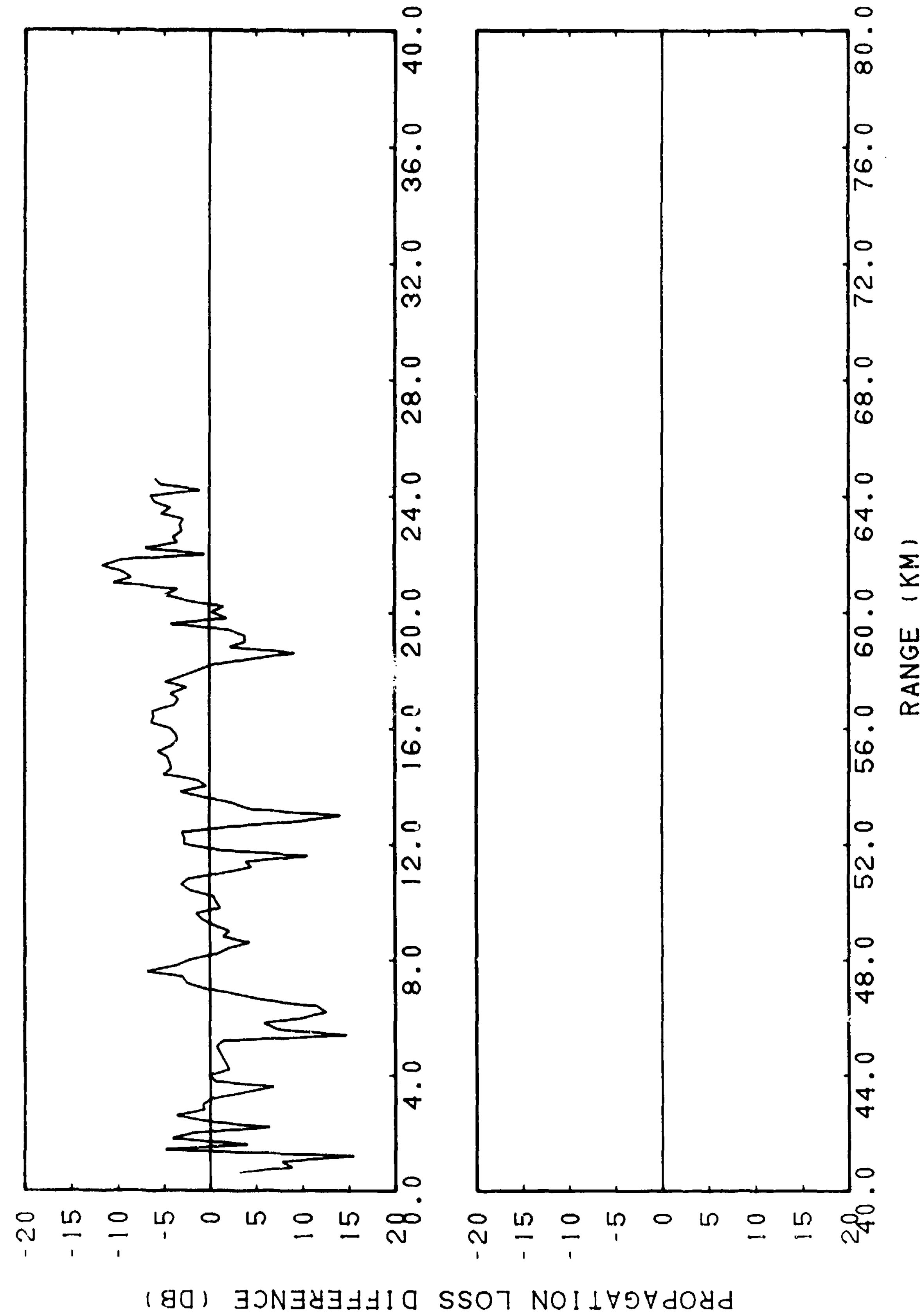


(C) Figure IIA-25. FACT Semi-coherent, Frequency = 1.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 6 Meters Subtracted from SUDS Data, Frequency = 1.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 6 Meters



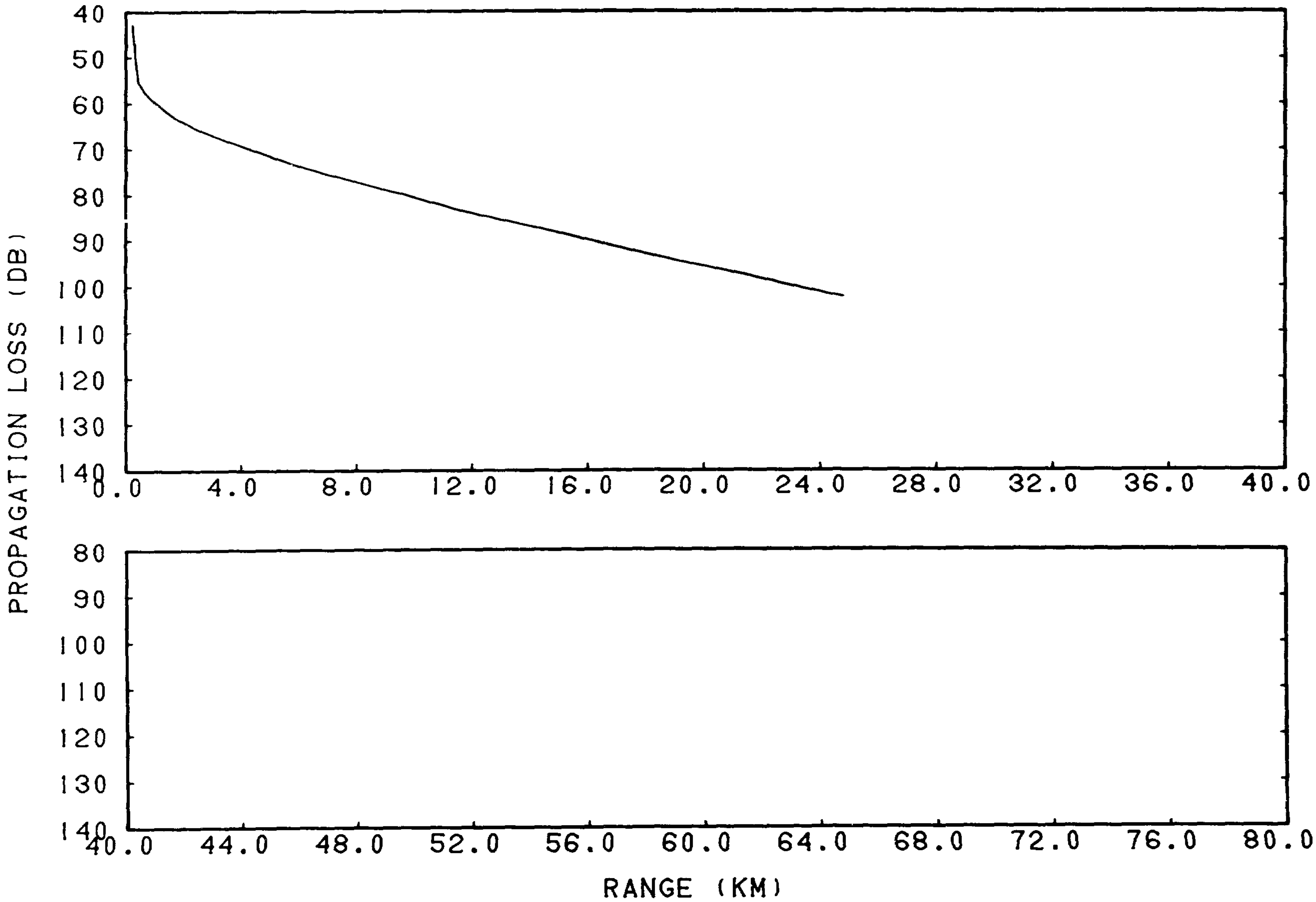
CONFIDENTIAL

(C) Figure IIA-26. FACT Semi-coherent, Frequency = 1.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 59 Meters Subtracted from SUDS Data, Frequency = 1.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 59 Meters



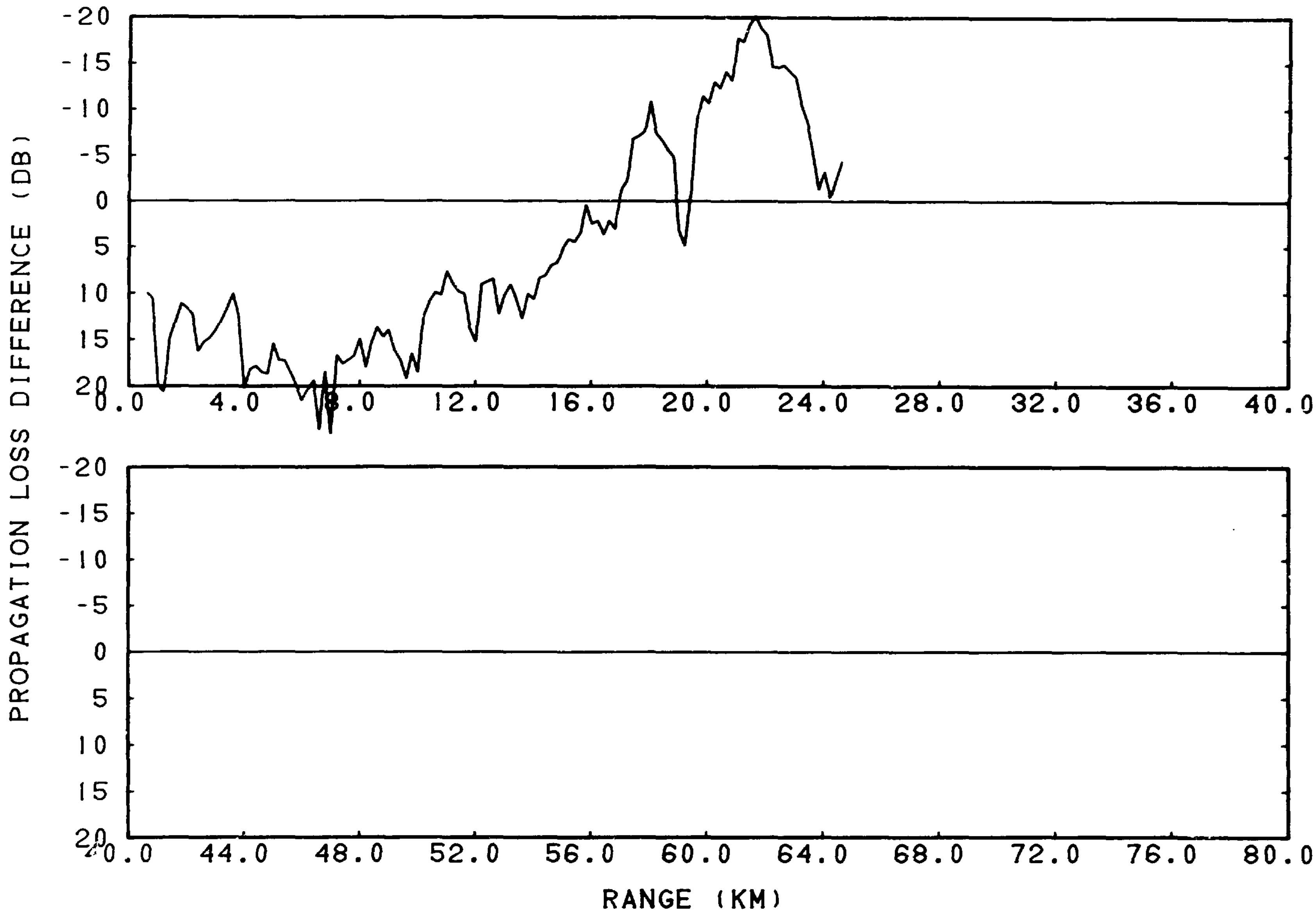
CONFIDENTIAL

(C) Figure IIA-27. FACT Semi-coherent, Frequency = 1.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 59 Meters



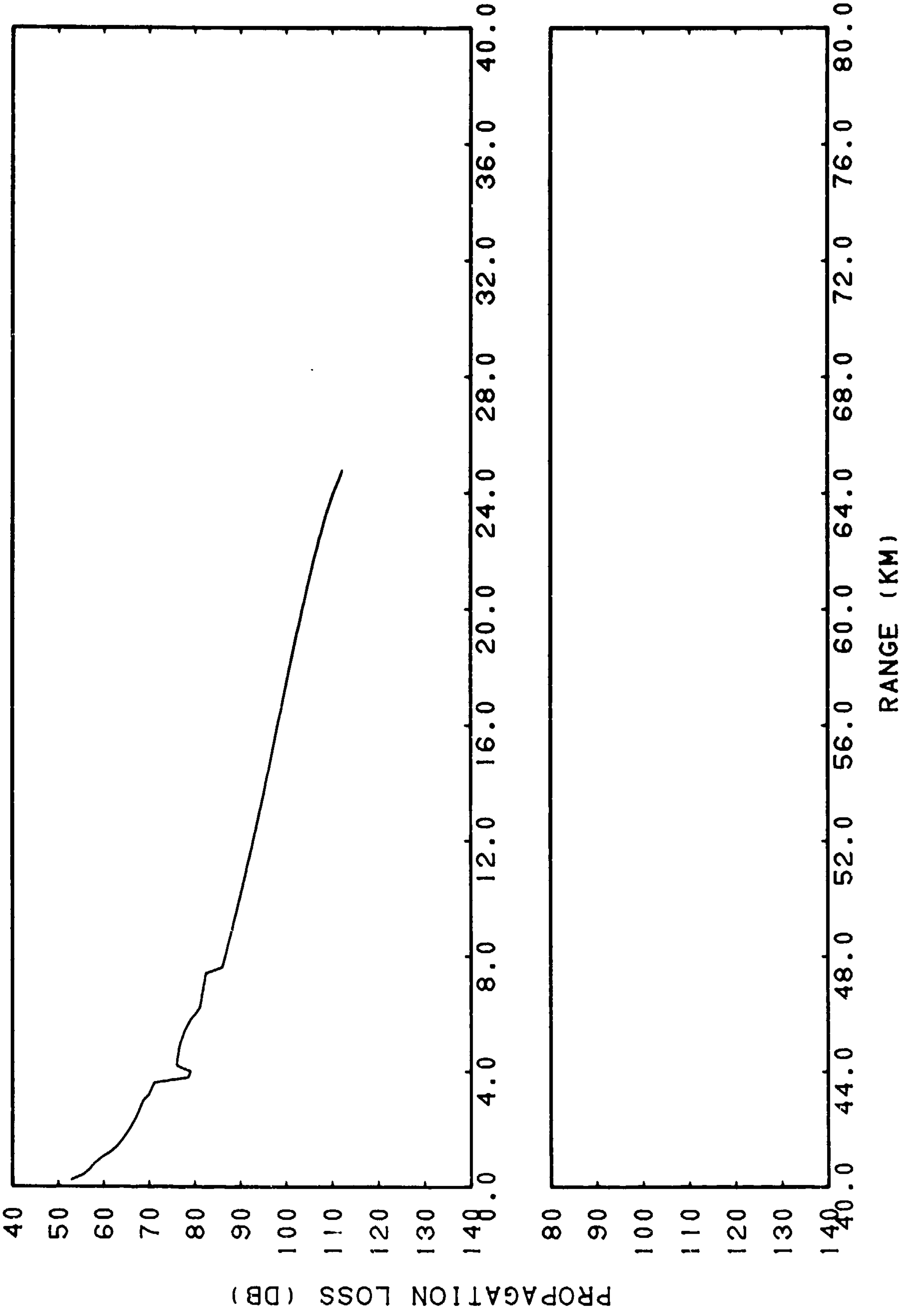
CONFIDENTIAL

(C) Figure IIA-28. FACT Semi-coherent, Frequency = 2.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 6 Meters



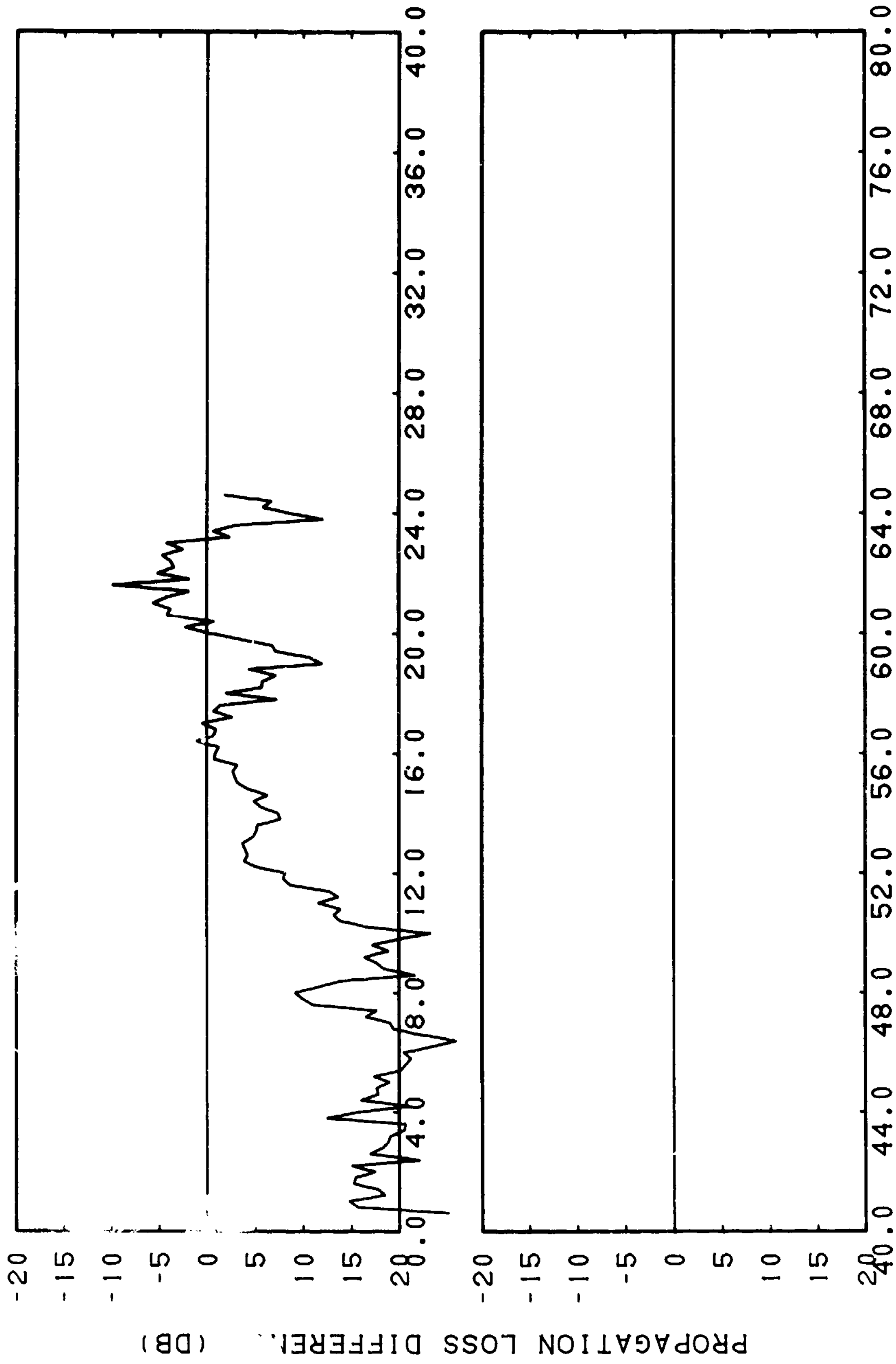
CONFIDENTIAL

(C) Figure IIA-29. FACT Semi-coherent, Frequency = 2.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 6 Meters Subtracted from SUDS Data, Frequency = 2.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 6 Meters



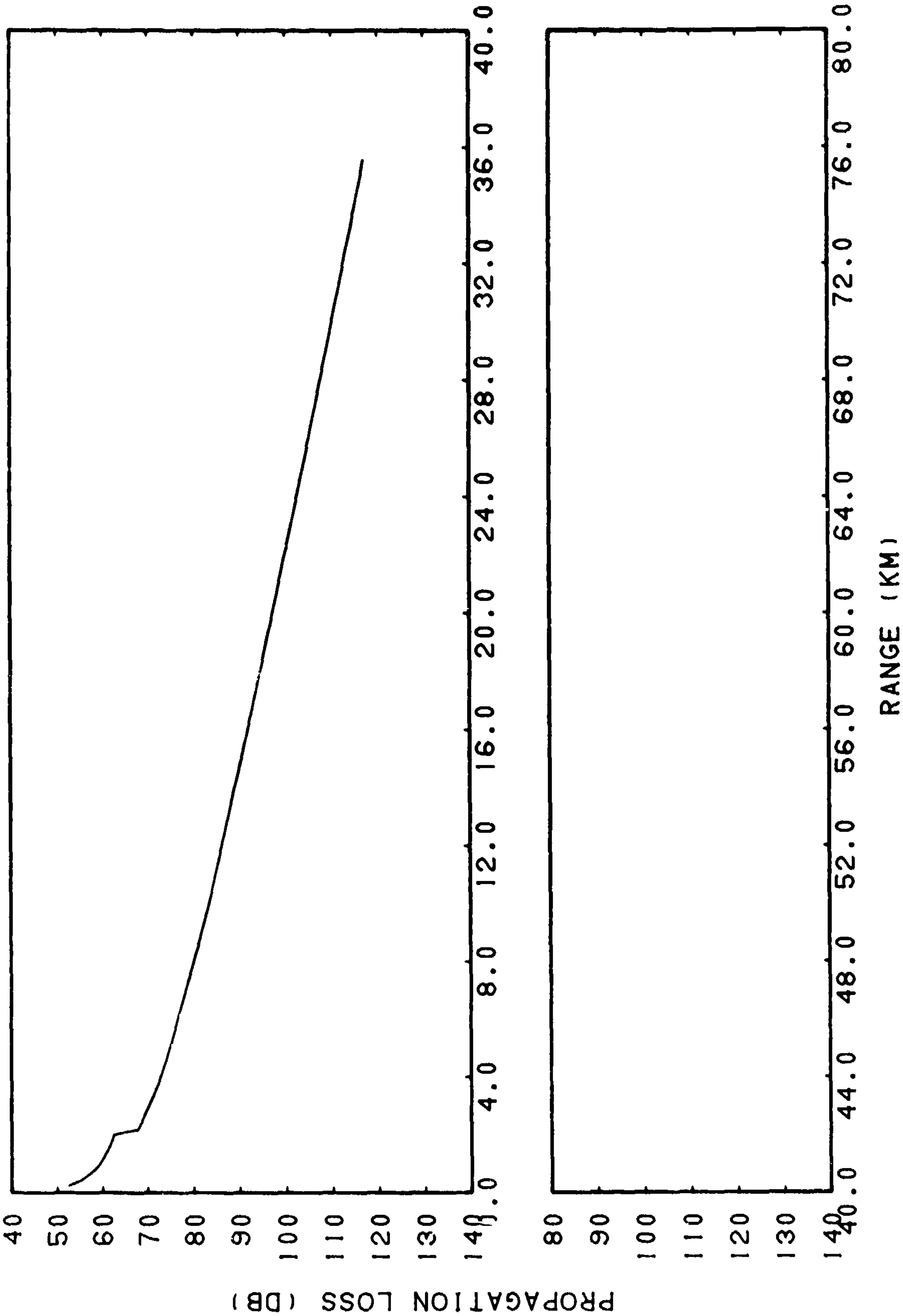
CONFIDENTIAL

(C) Figure IIA-30. FACT Semi-coherent, Frequency = 2.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 59 Meters



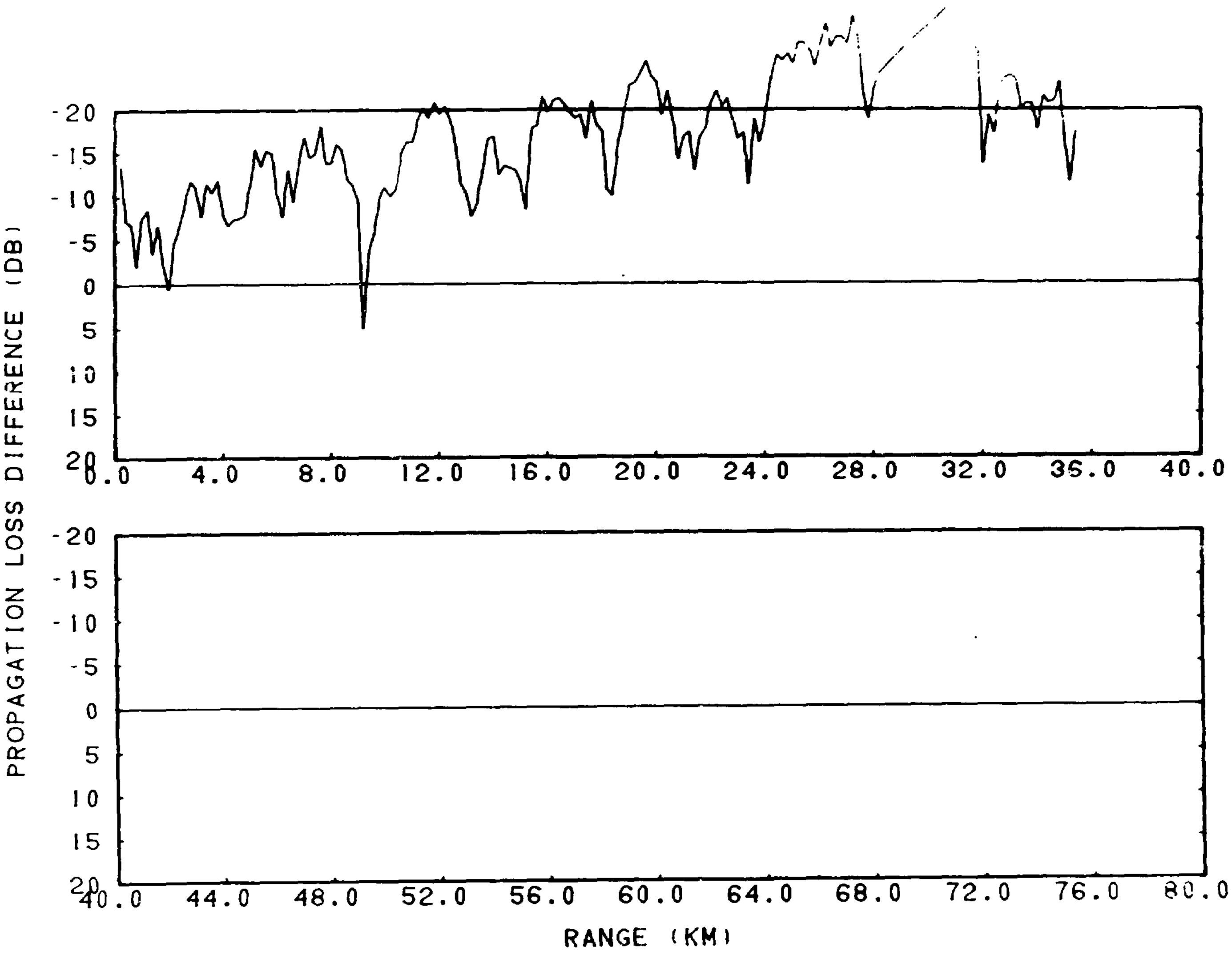
CONFIDENTIAL

(C) Figure IIA-31. FACT Semi-coherent, Frequency = 2.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 59 Meters Subtracted from SUDS Data, Frequency = 2.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 59 Meters



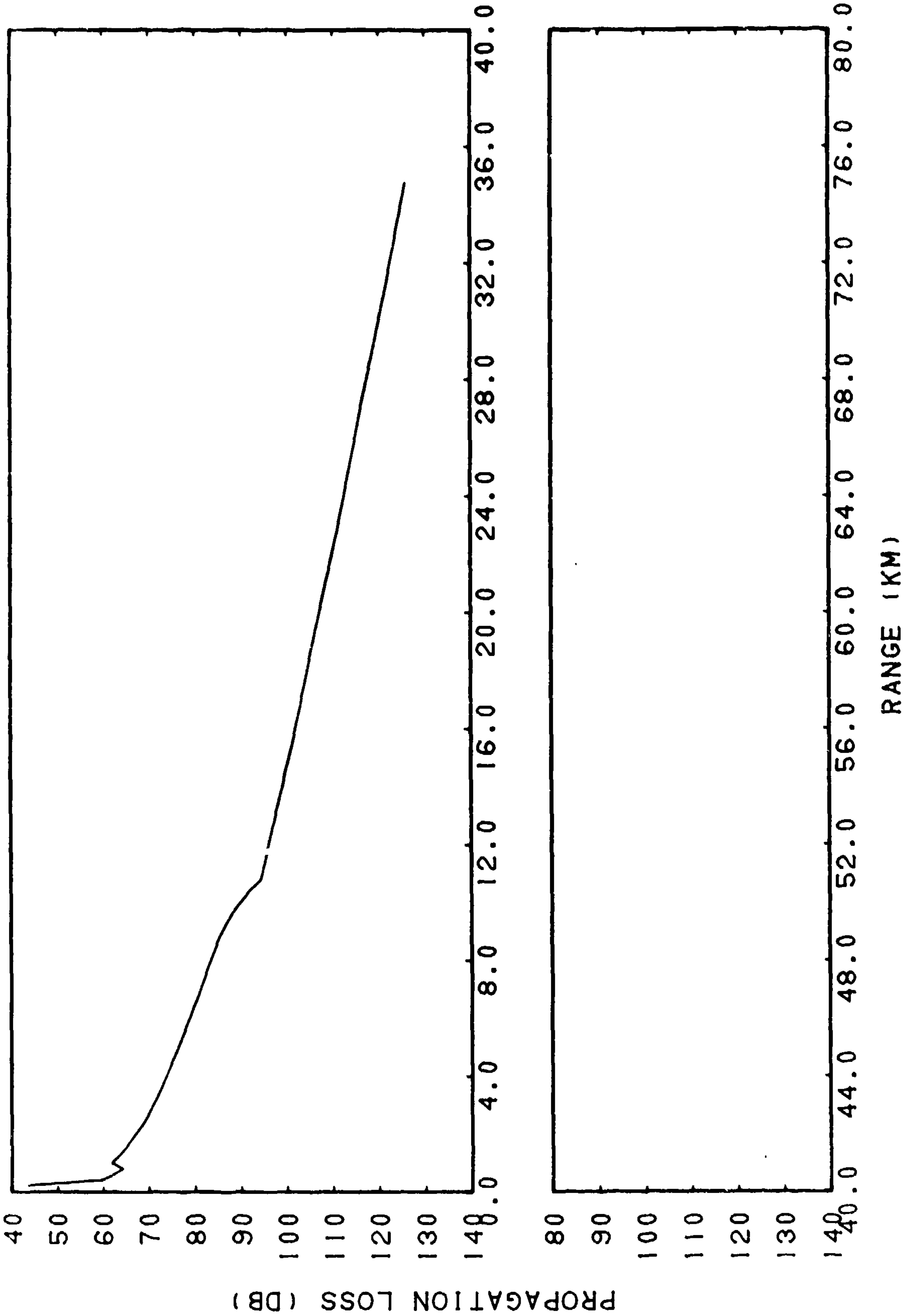
CONFIDENTIAL

(C) Figure IIA-32. FACT Semi-coherent, Frequency = 3.5 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 17 Meters



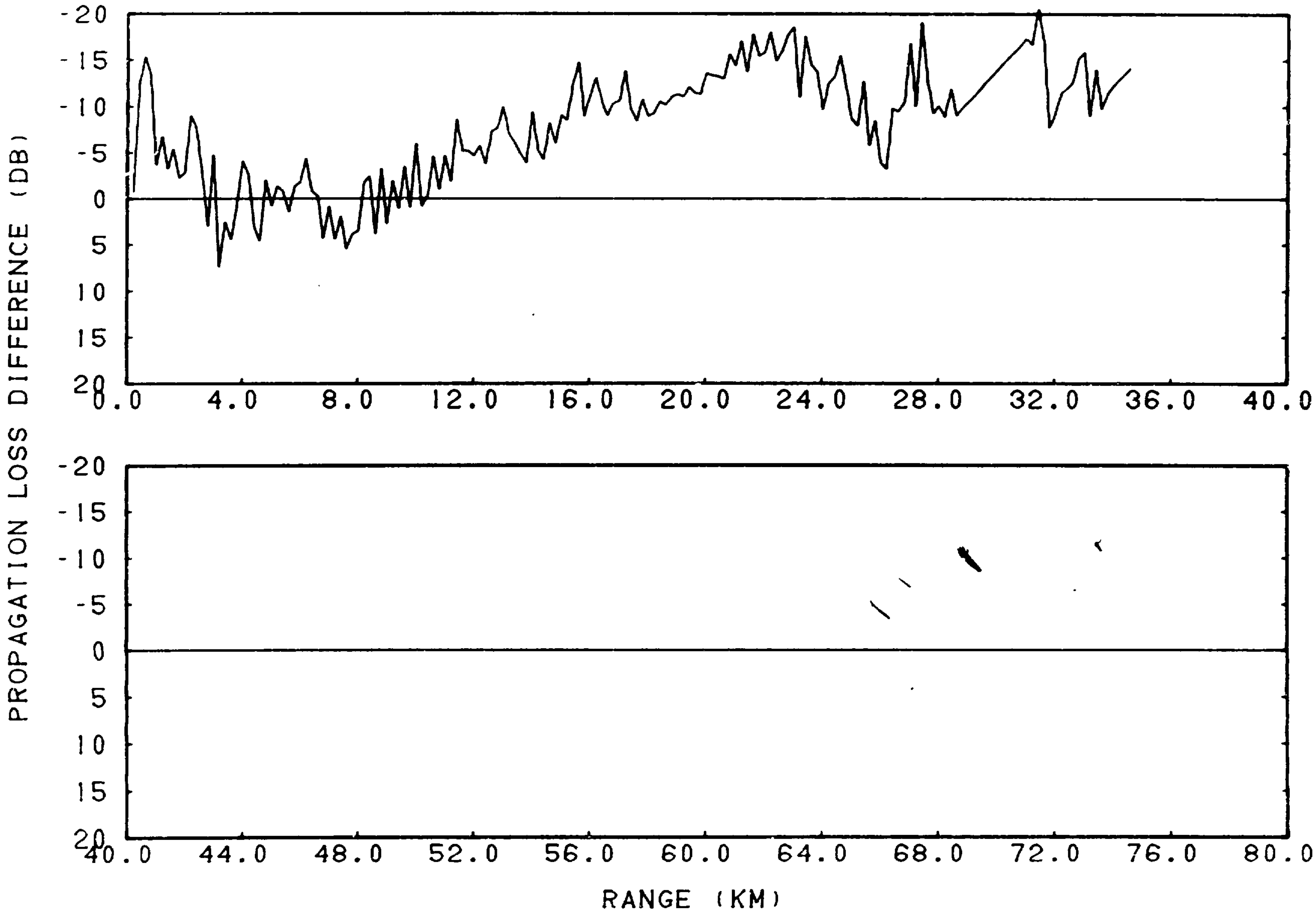
CONFIDENTIAL

(C) Figure IIA-33. FACT Semi-coherent, Frequency = 3.5 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 17 Meters Subtracted from SUDS Data, Frequency = 3.5 Kilohertz, Source Depth = 45 Meters, Freceiver Depth = 17 Meters



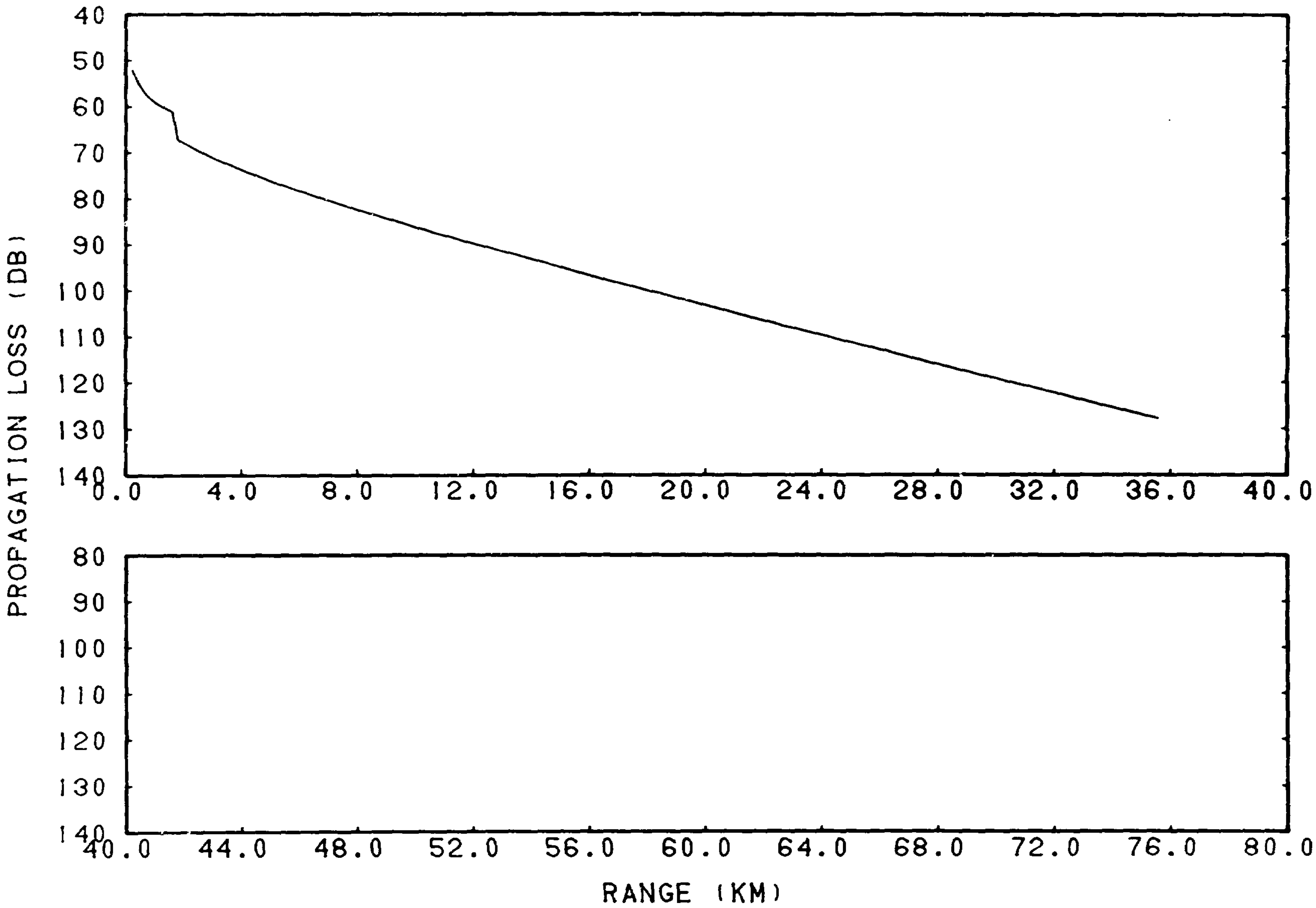
CONFIDENTIAL

(C) Figure IIA-34. FACT Semi-coherent, Frequency = 3.5 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 112 Meters



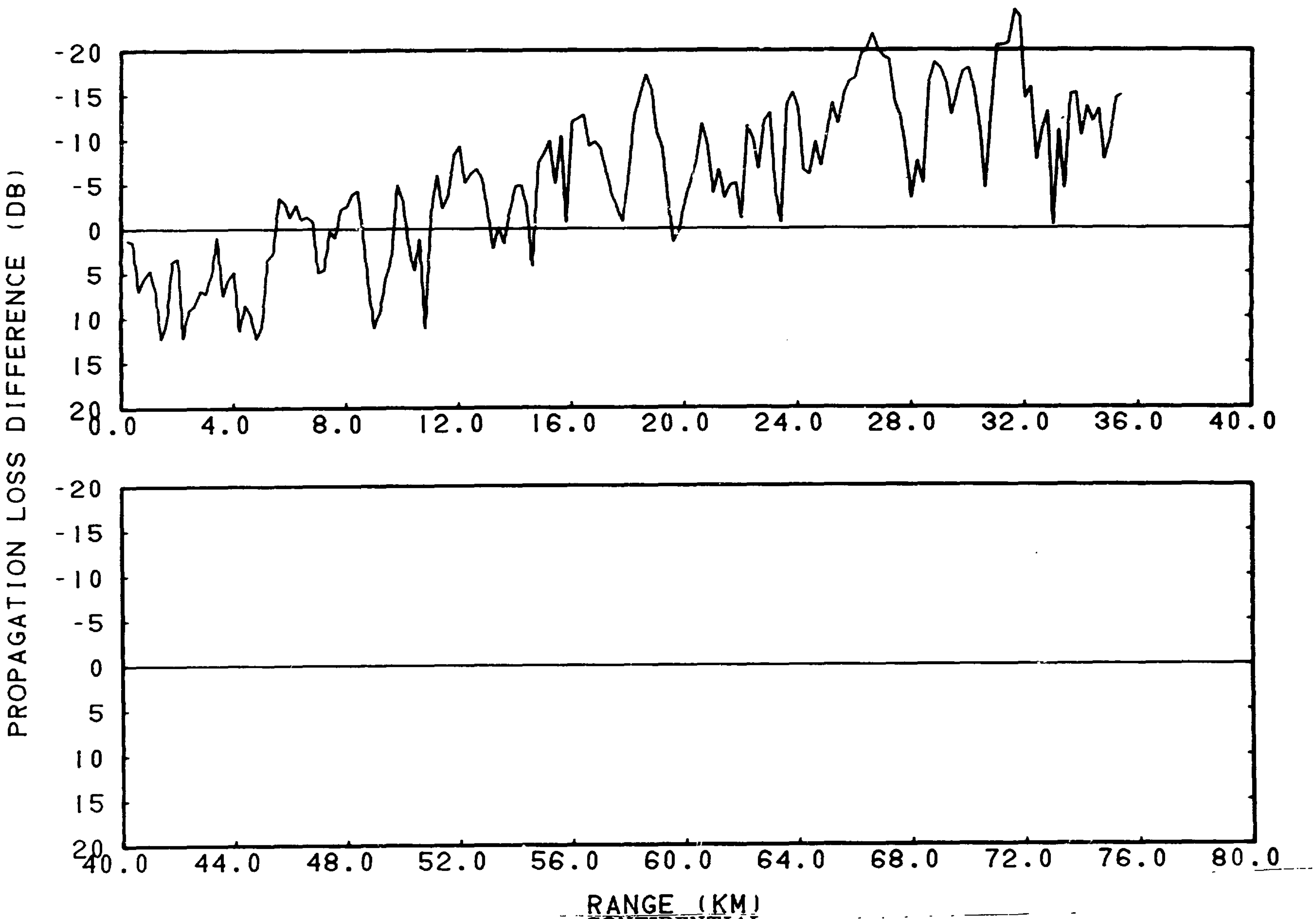
CONFIDENTIAL

(C) Figure IIA-35. FACT Semi-coherent, Frequency = 3.5 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 112 Meters Subtracted from SUDS Data, Frequency - 3.5 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 112 Meters



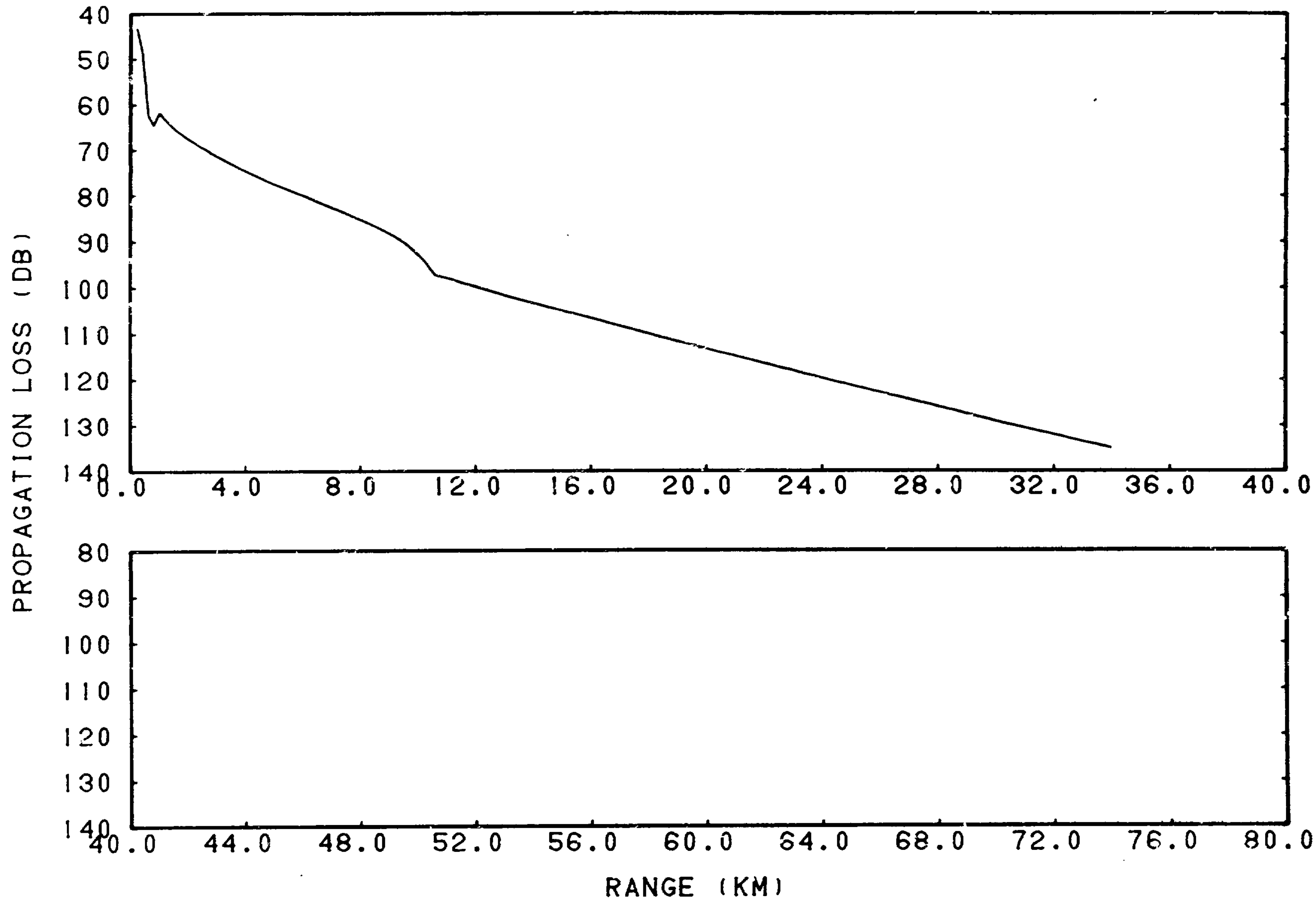
CONFIDENTIAL

(C) Figure IIA-36. FACT Semi-coherent, Frequency = 5.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 17 Meters



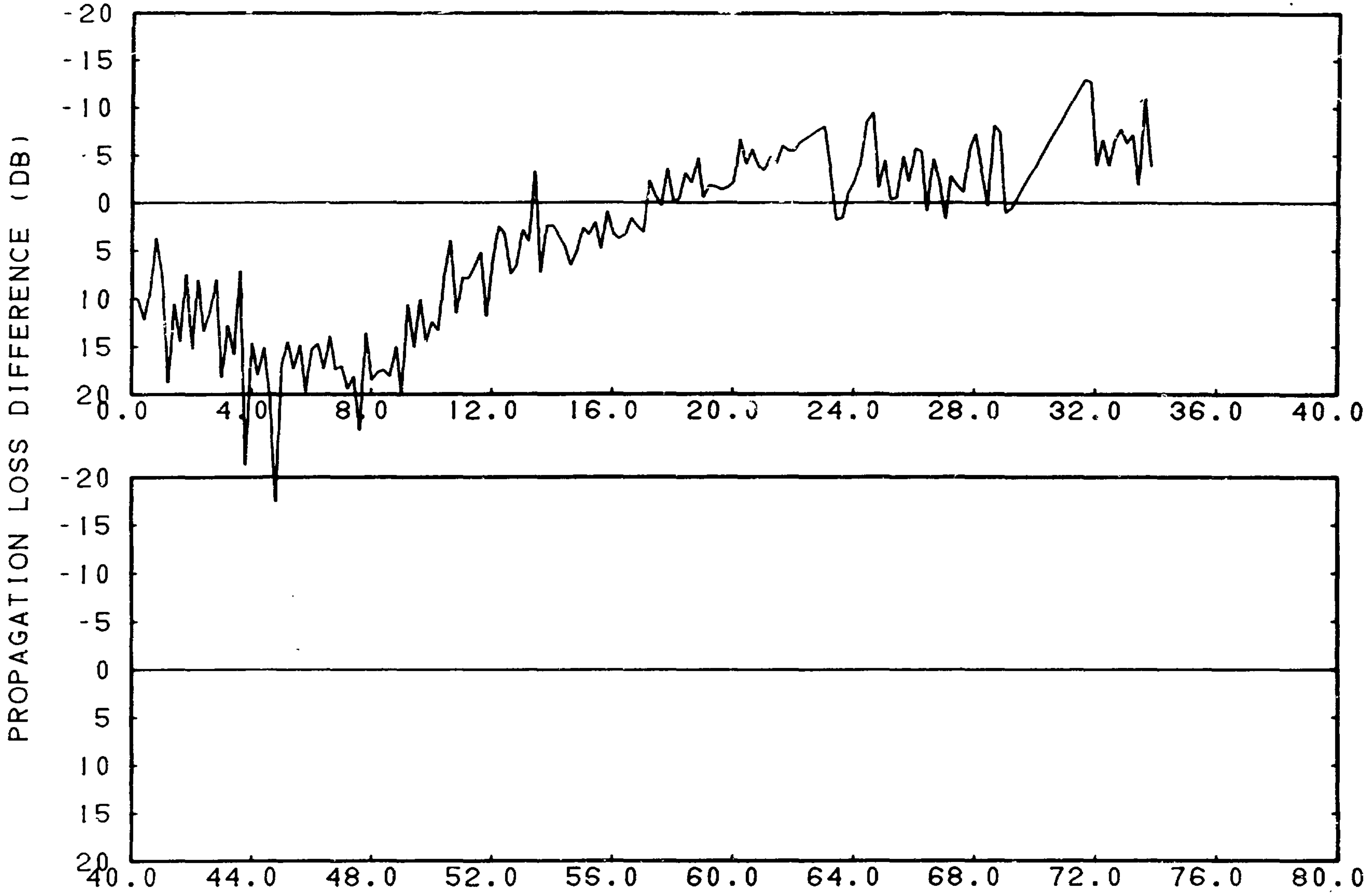
CONFIDENTIAL

(C) Figure IIA-37. FACT Semi-coherent, Frequency = 5.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 17 Meters Subtracted from SUDS Data, Frequency = 5.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 17 Meters



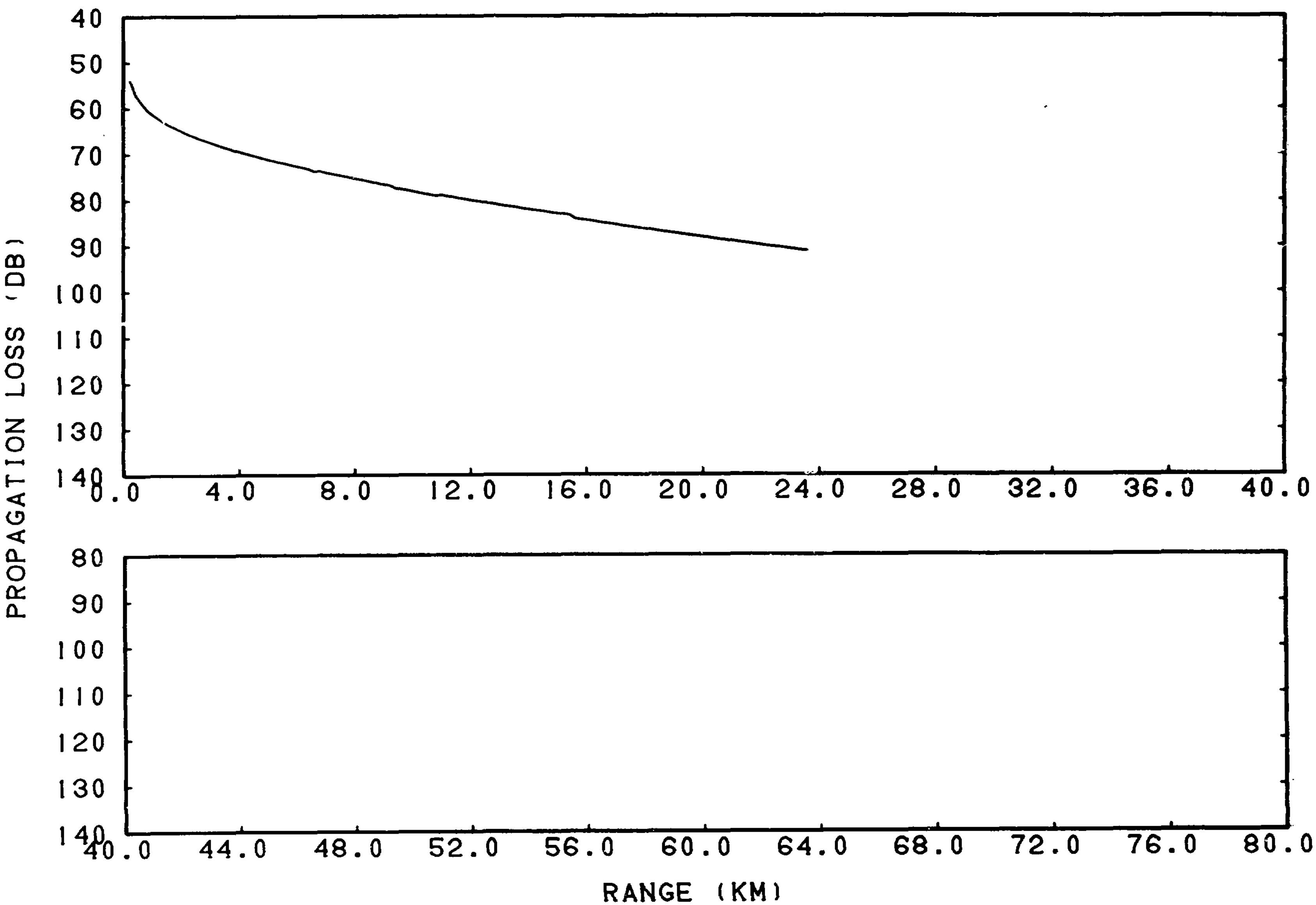
CONFIDENTIAL

(C) Figure IIA-38. FACT Semi-coherent, Frequency = 5.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 112 Meters



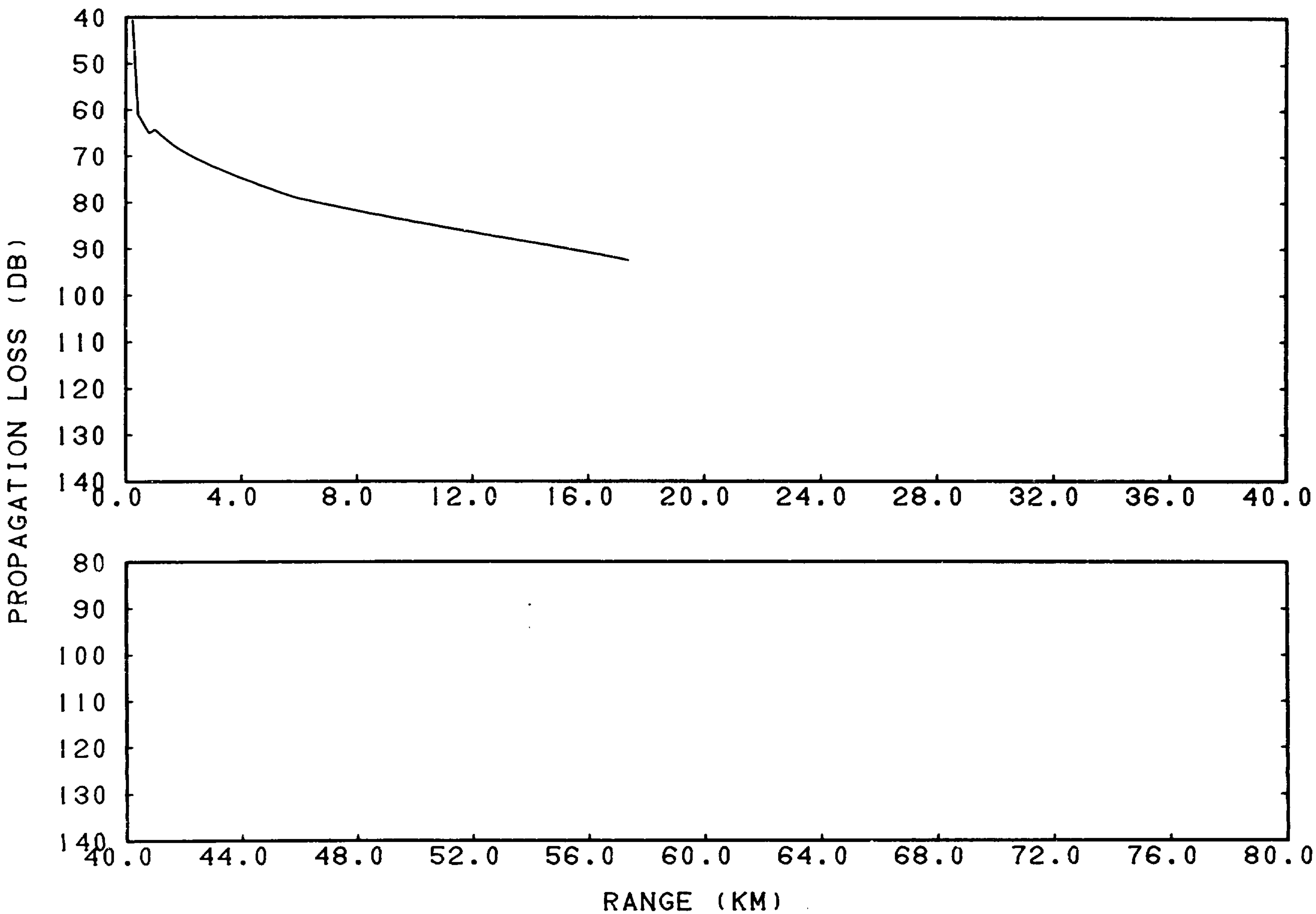
CONFIDENTIAL

(C) Figure IIA-39. FACT Semi-coherent, Frequency = 5.0 Kilohertz Source Depth = 42 Meters, Receiver Depth = 112 Meters Subtracted from SUDS Data, Frequency = 5.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 112 Meters



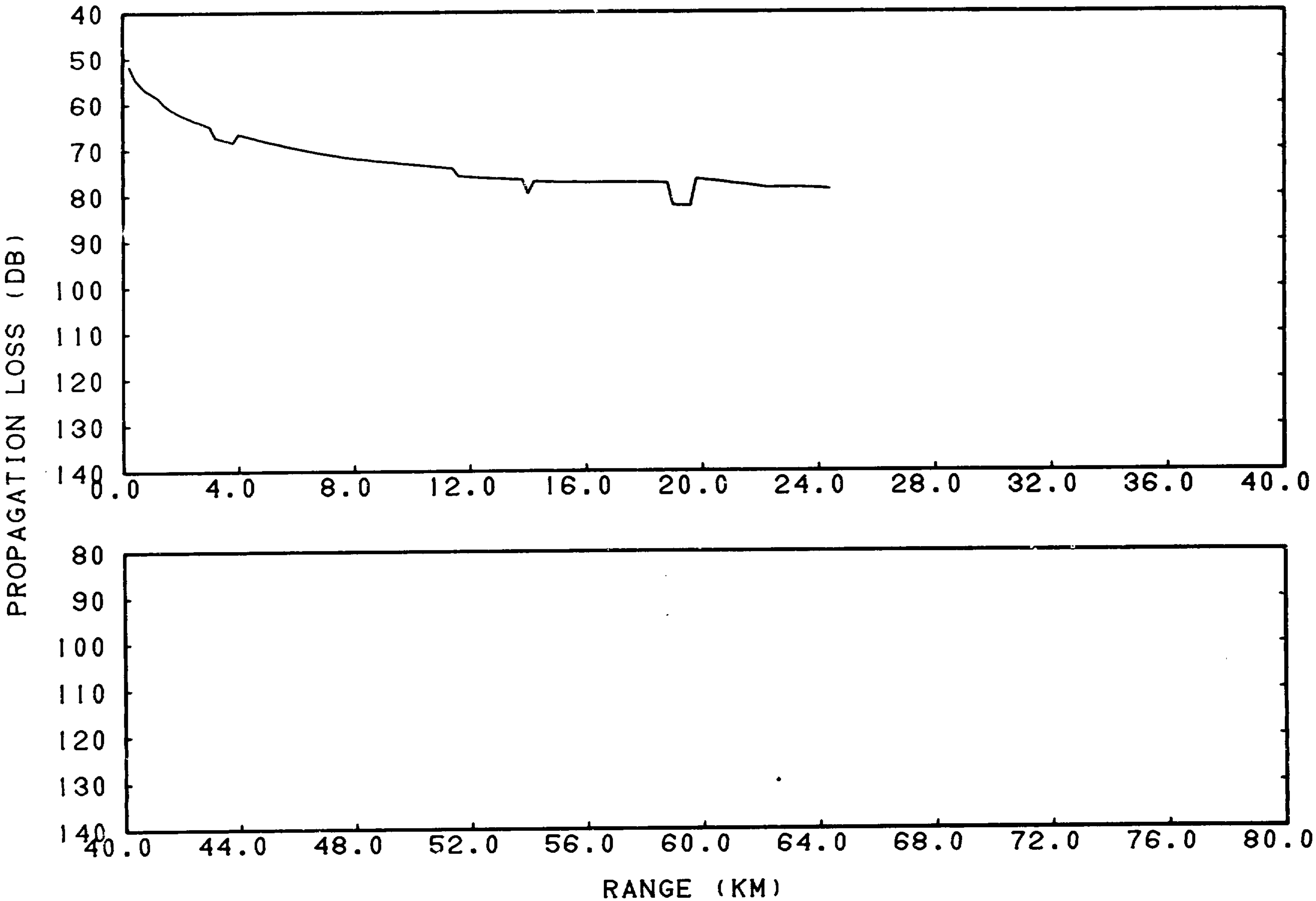
CONFIDENTIAL

(C) Figure IIA-40. FACT Coherent, Frequency = 0.4 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 17 Meters



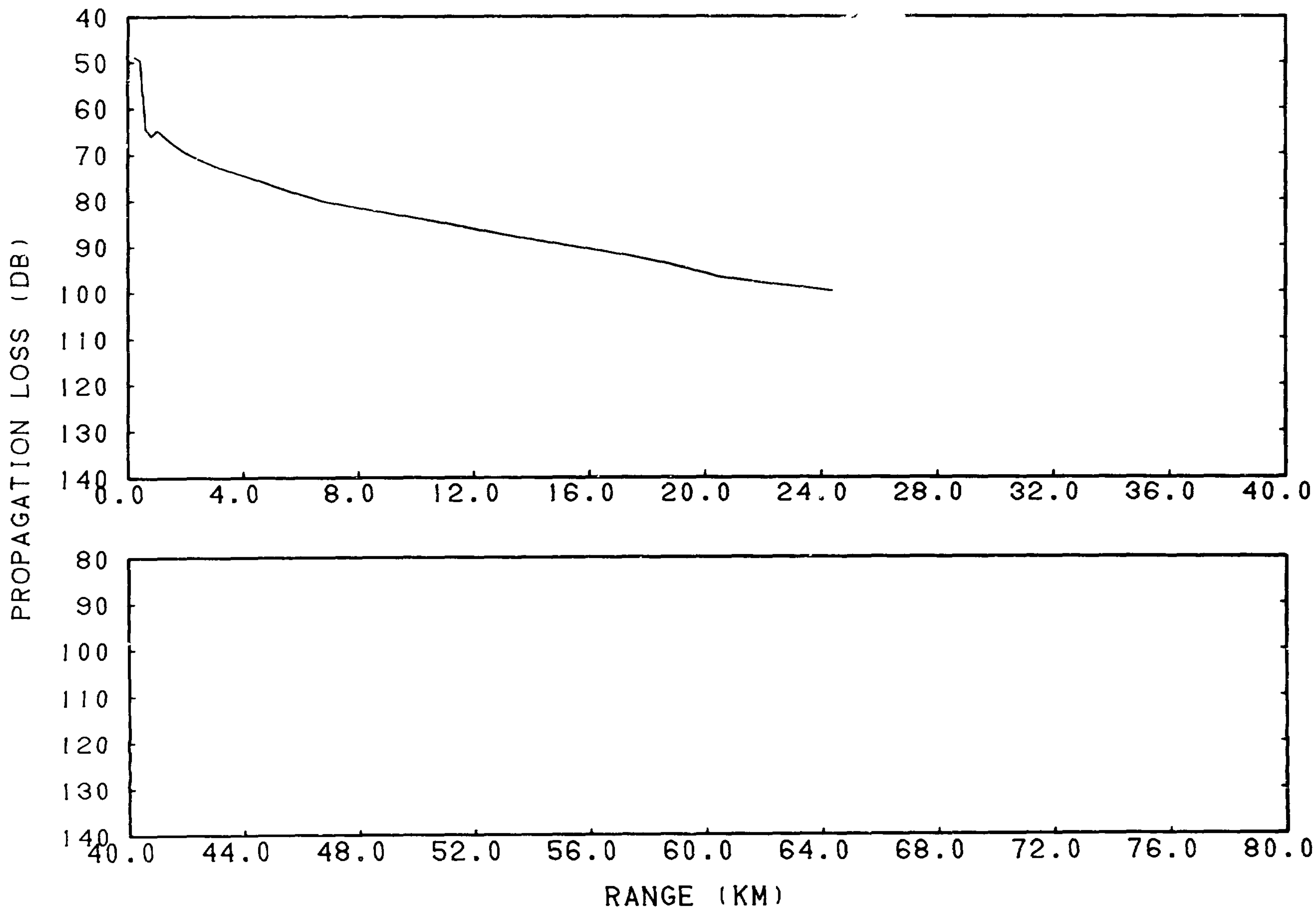
CONFIDENTIAL

(C) Figure IIA-41. FACT Coherent, Frequency = 0.4 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 112 Meters



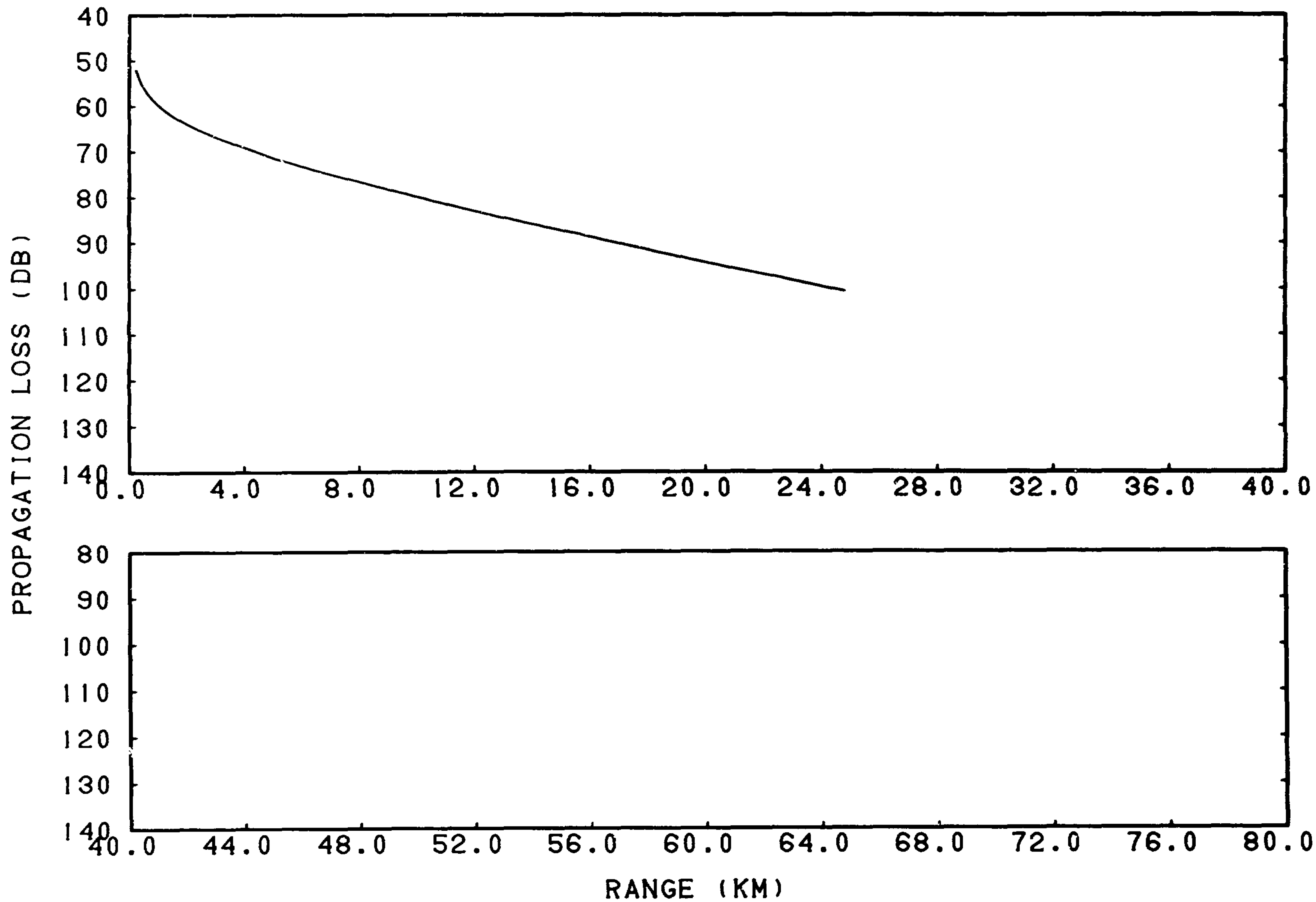
CONFIDENTIAL

(C) Figure IIA-42. FACT Coherent, Frequency = 1.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 43 Meters



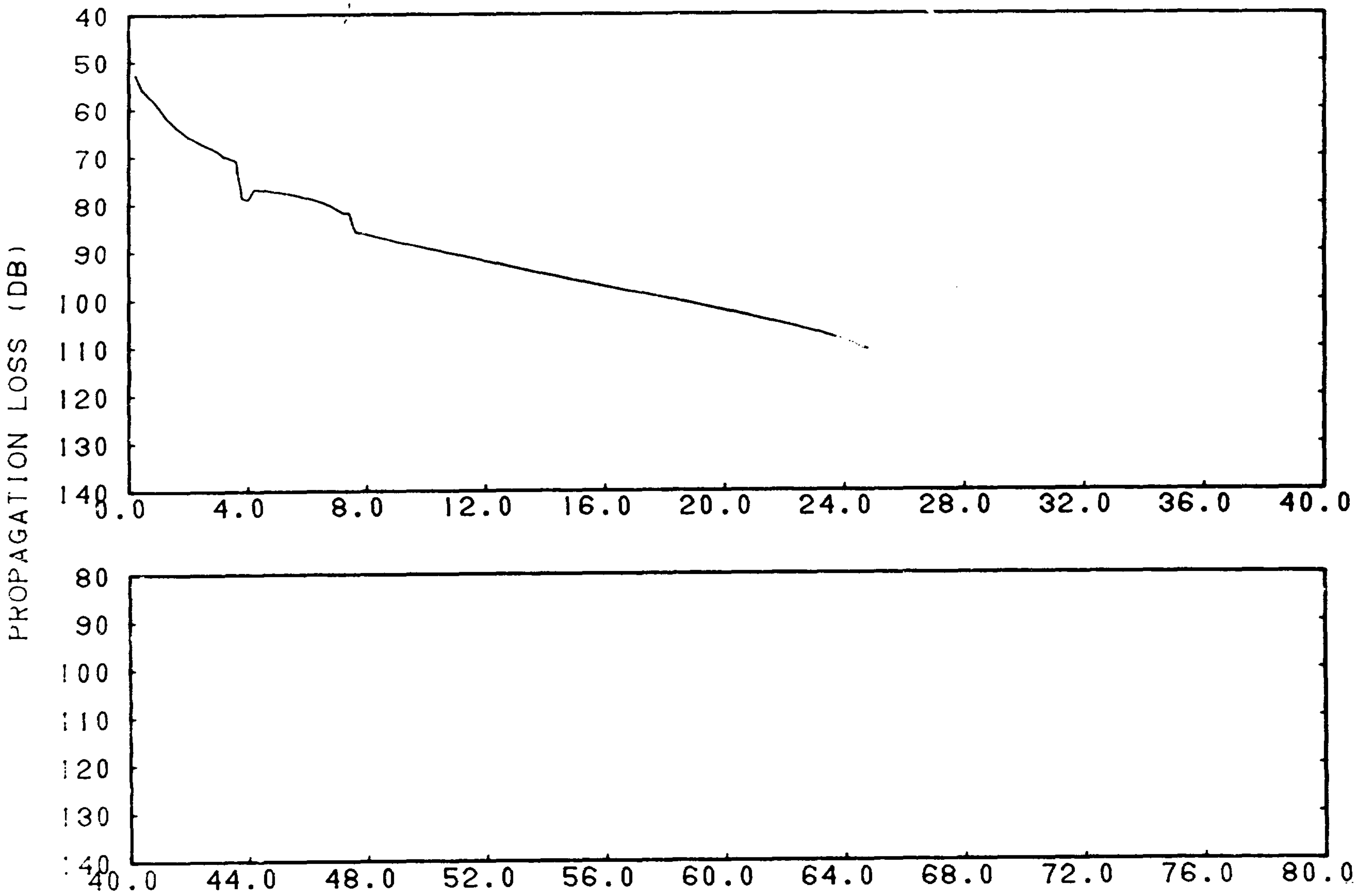
CONFIDENTIAL

(C) Figure IIA-43. FACT Coherent, Frequency = 1.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 112 Meters



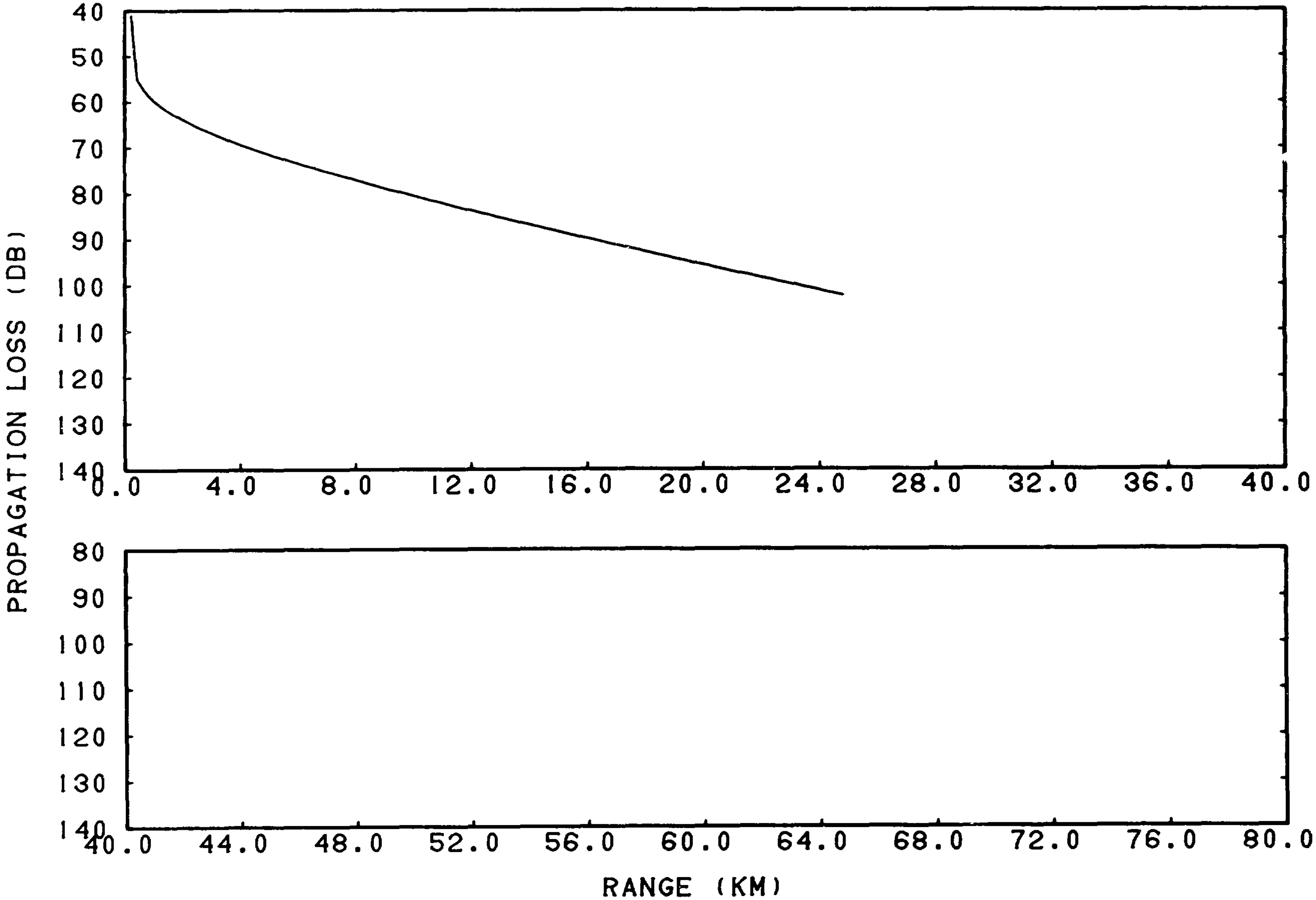
CONFIDENTIAL

(C) Figure IIA-44. FACT Coherent, Frequency = 1.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 6 Meters



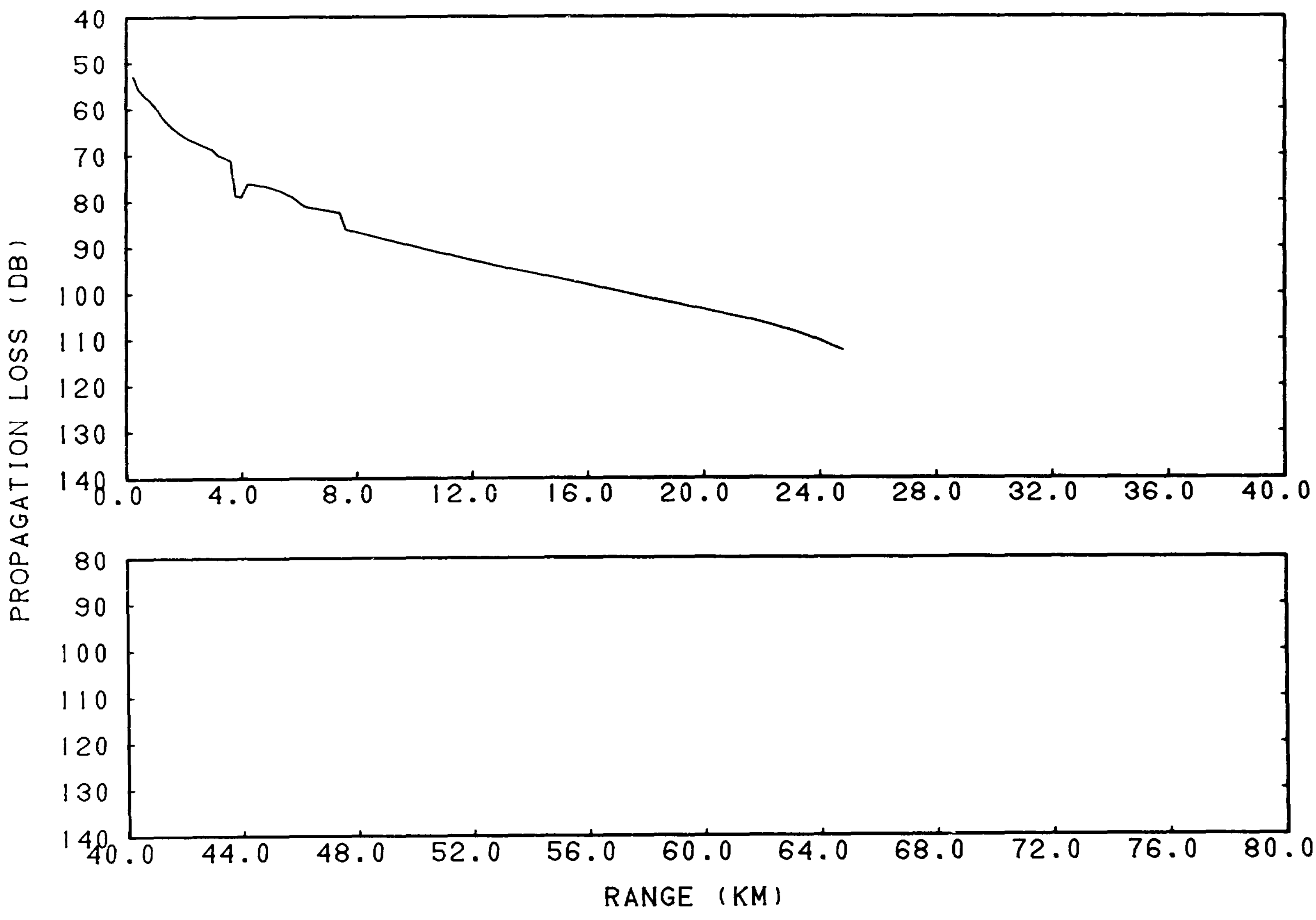
CONFIDENTIAL

(C) Figure IIA-45. FACT Coherent, Frequency = 1.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 59 Meters



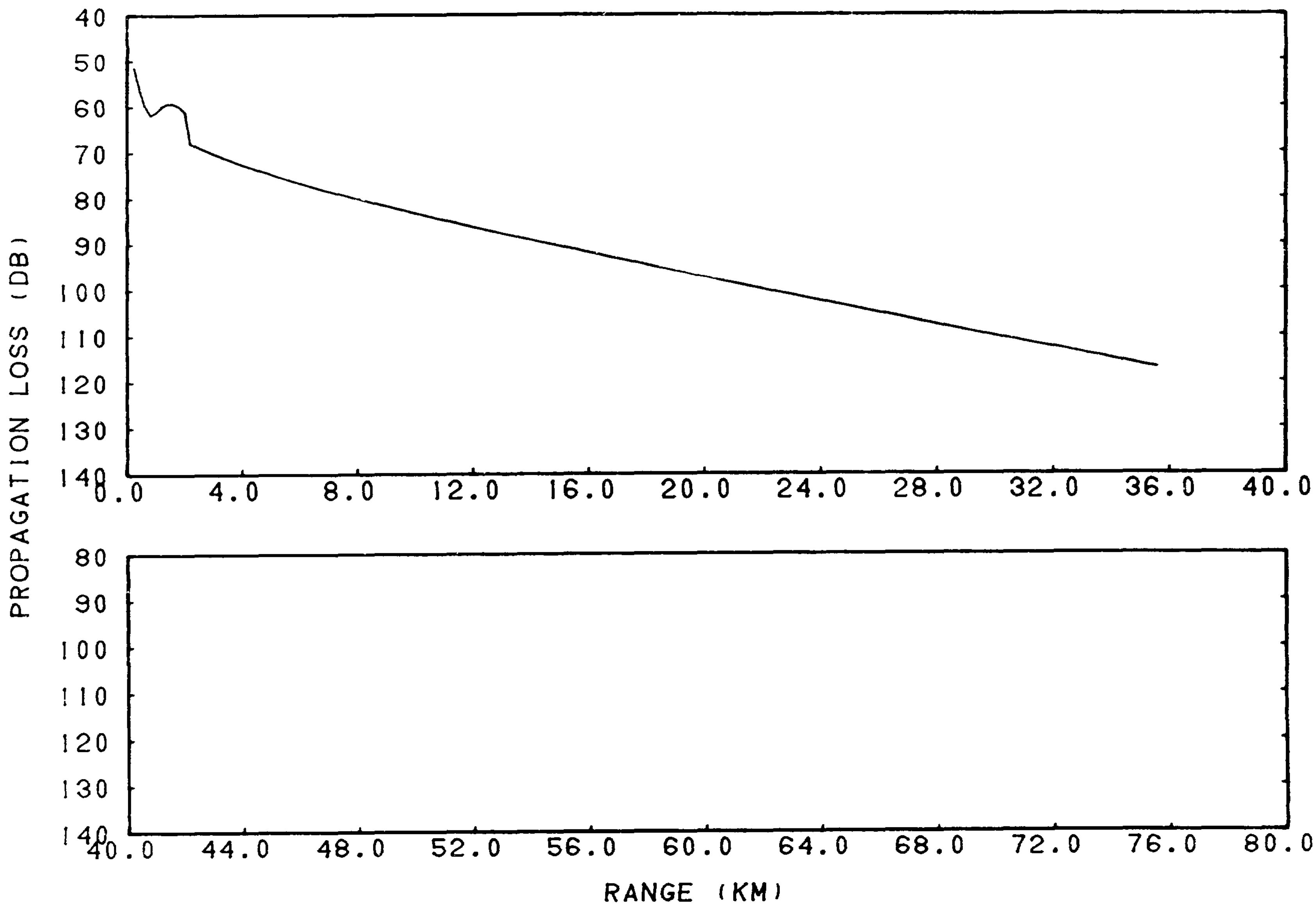
CONFIDENTIAL

(C) Figure IIA-46. FACT Coherent, Frequency = 2.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 6 Meters



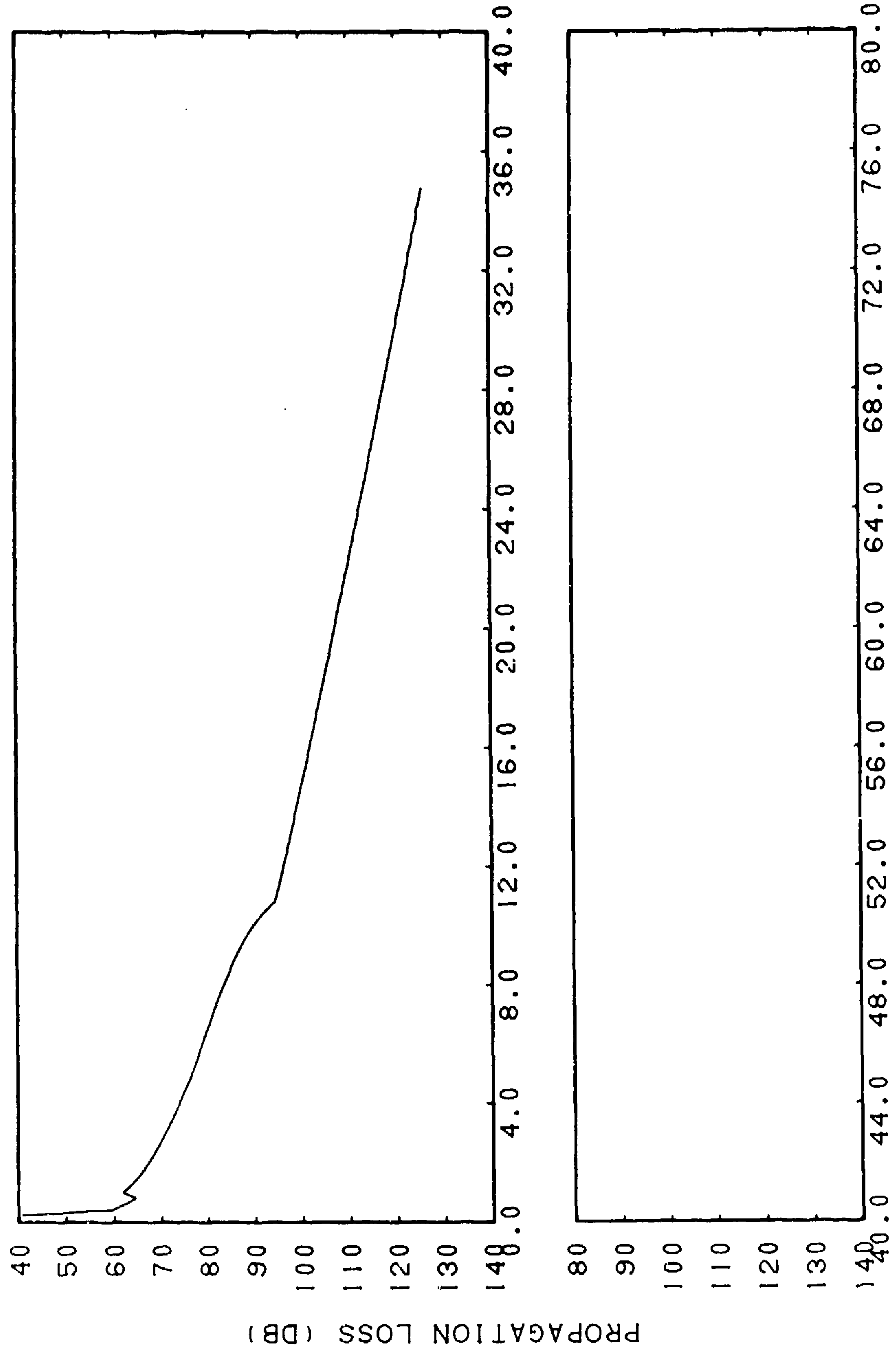
CONFIDENTIAL

(C) Figure IIA-47. FACT Coherent, Frequency = 2.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 59 Meters



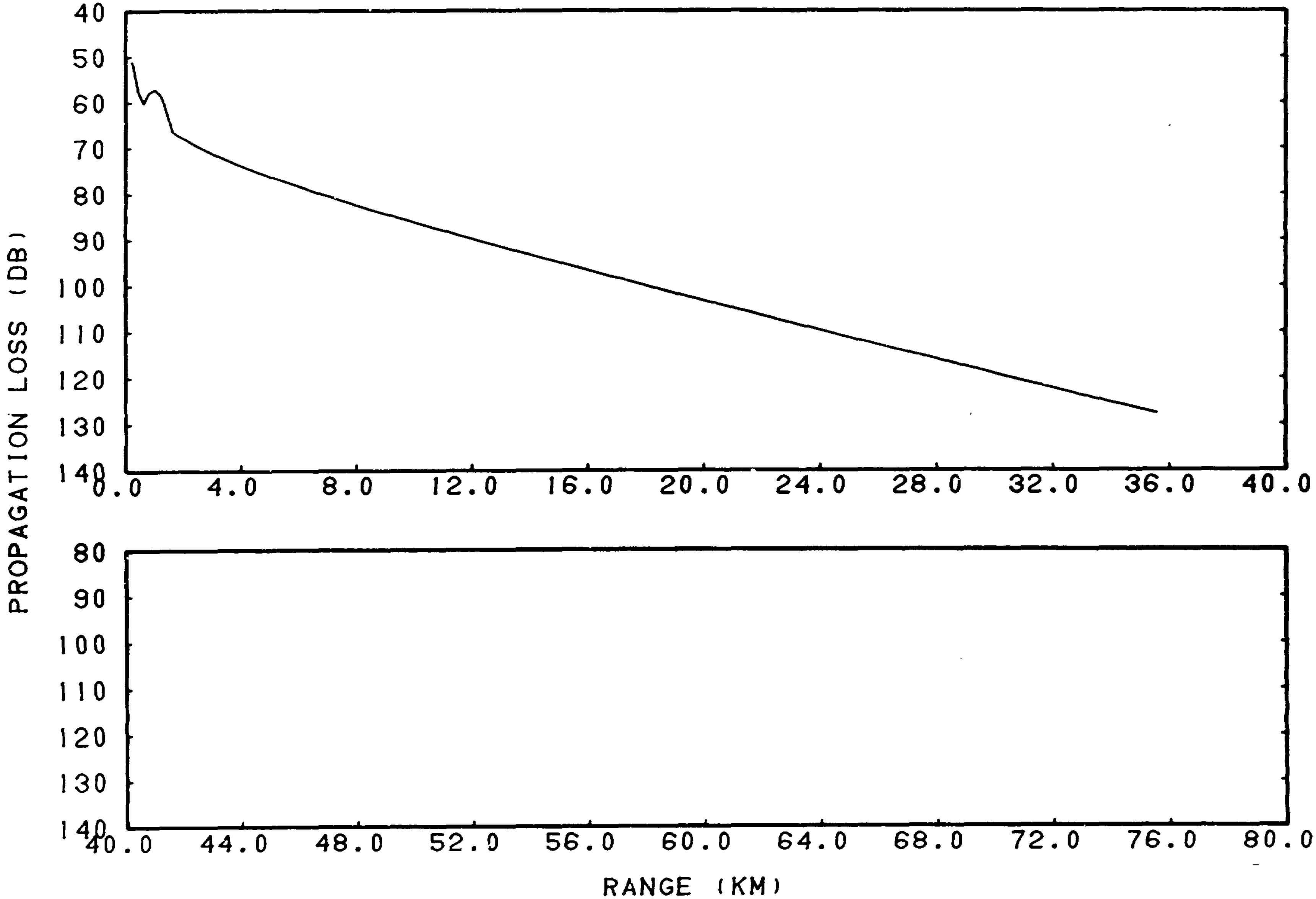
CONFIDENTIAL

(C) Figure IIA-48. FACT Coherent, Frequency = 3.5 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 17 Meters



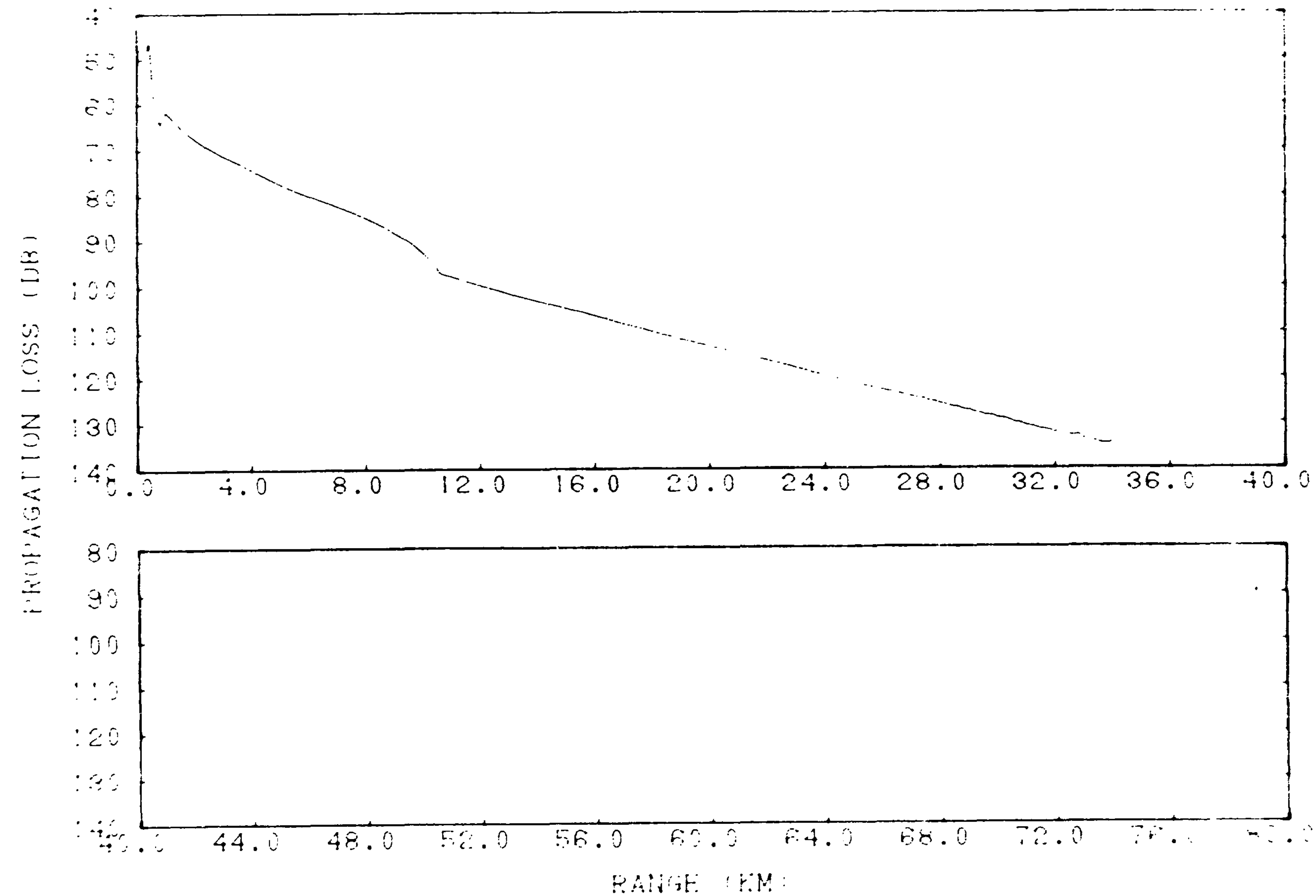
CONFIDENTIAL

(C) Figure IIA-49. FACT Coherent, Frequency = 3.5 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 112 Meters



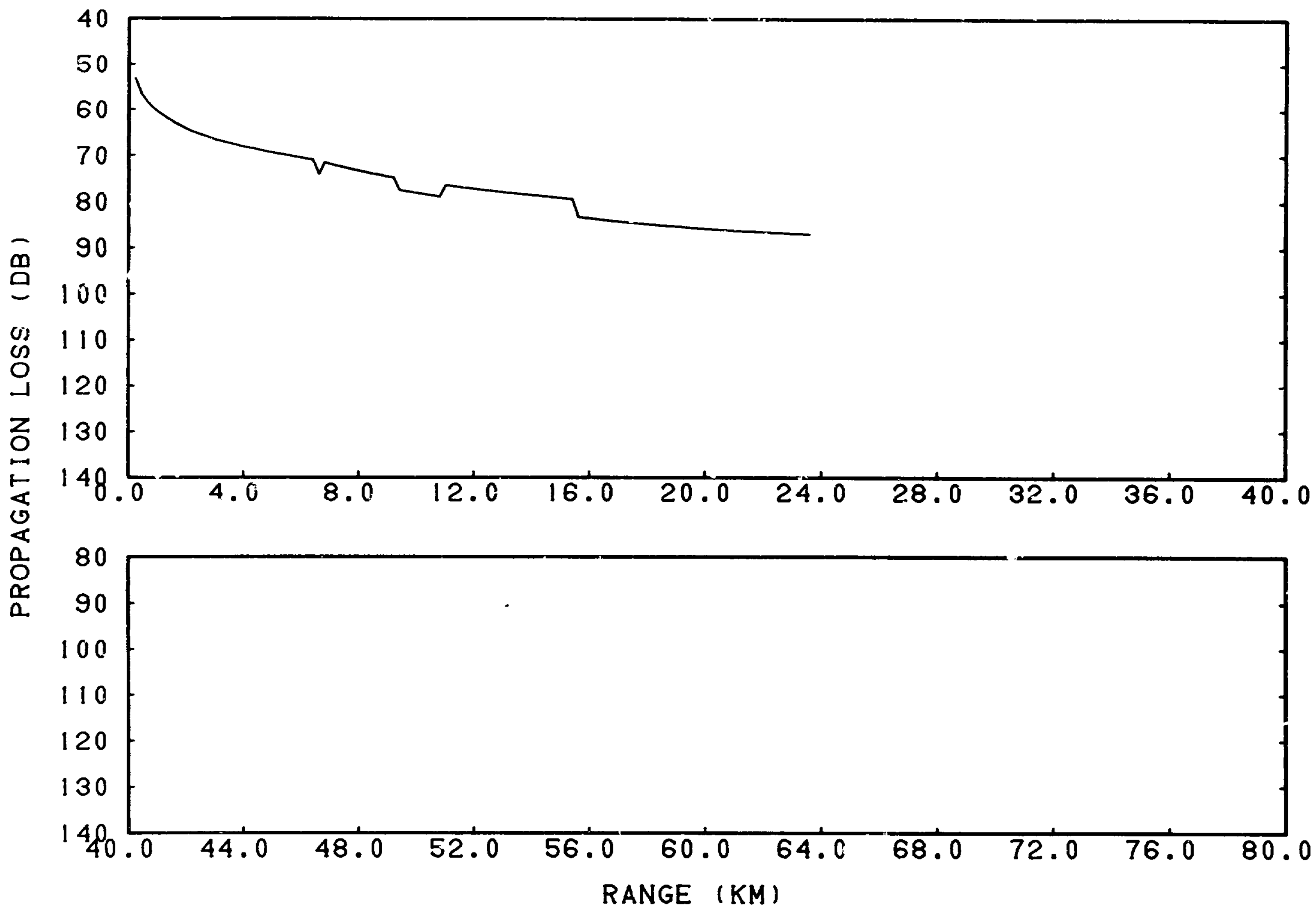
CONFIDENTIAL

(C) Figure IIA-50. FACT Coherent, Frequency = 5.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 17 Meters



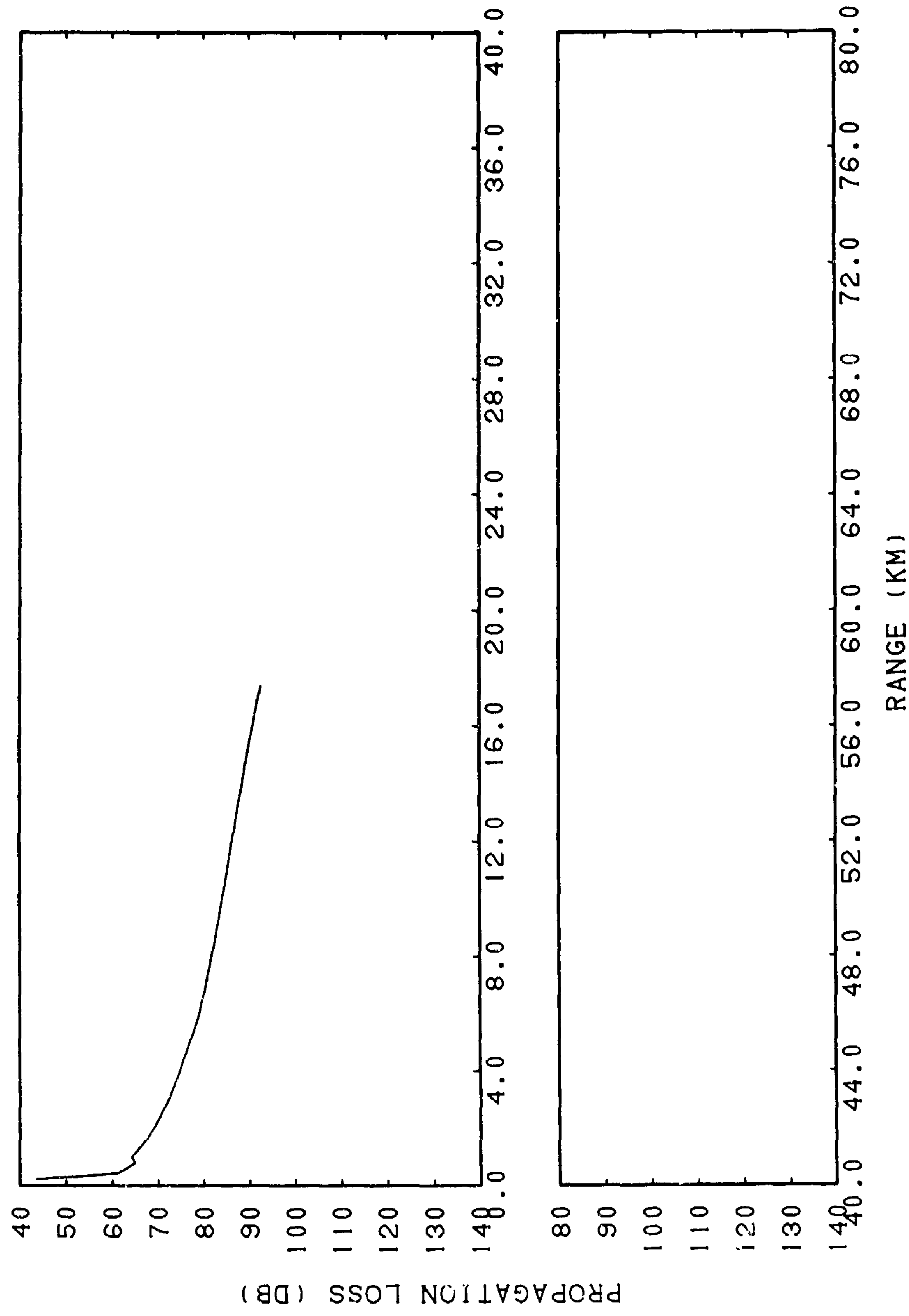
CONFIDENTIAL

(C) Figure IIA-51. FACT Coherent, Frequency = 5.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 112 Meters



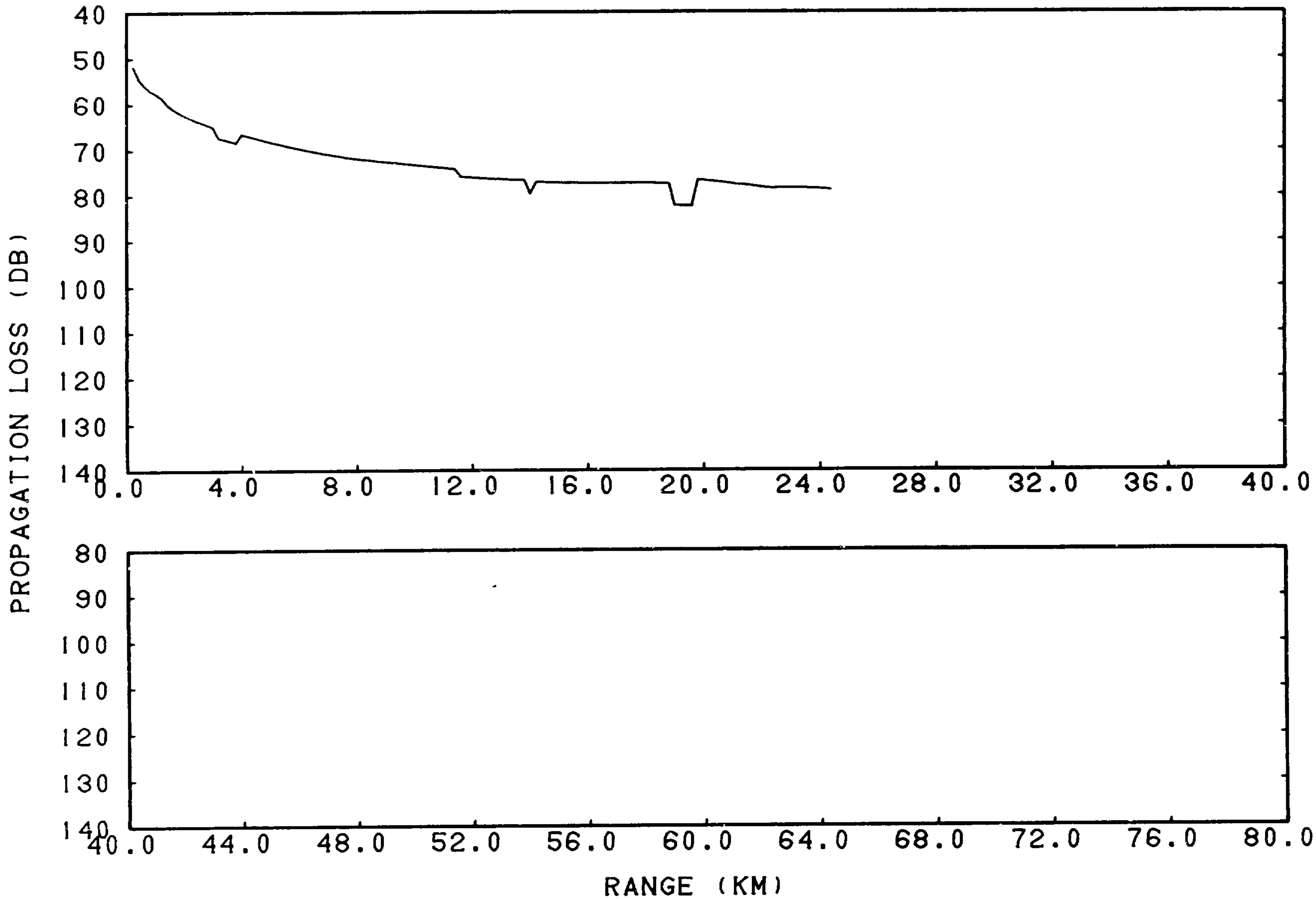
CONFIDENTIAL

(C) Figure IIA-52. FACT Incoherent, Frequency = 0.4 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 17 Meters



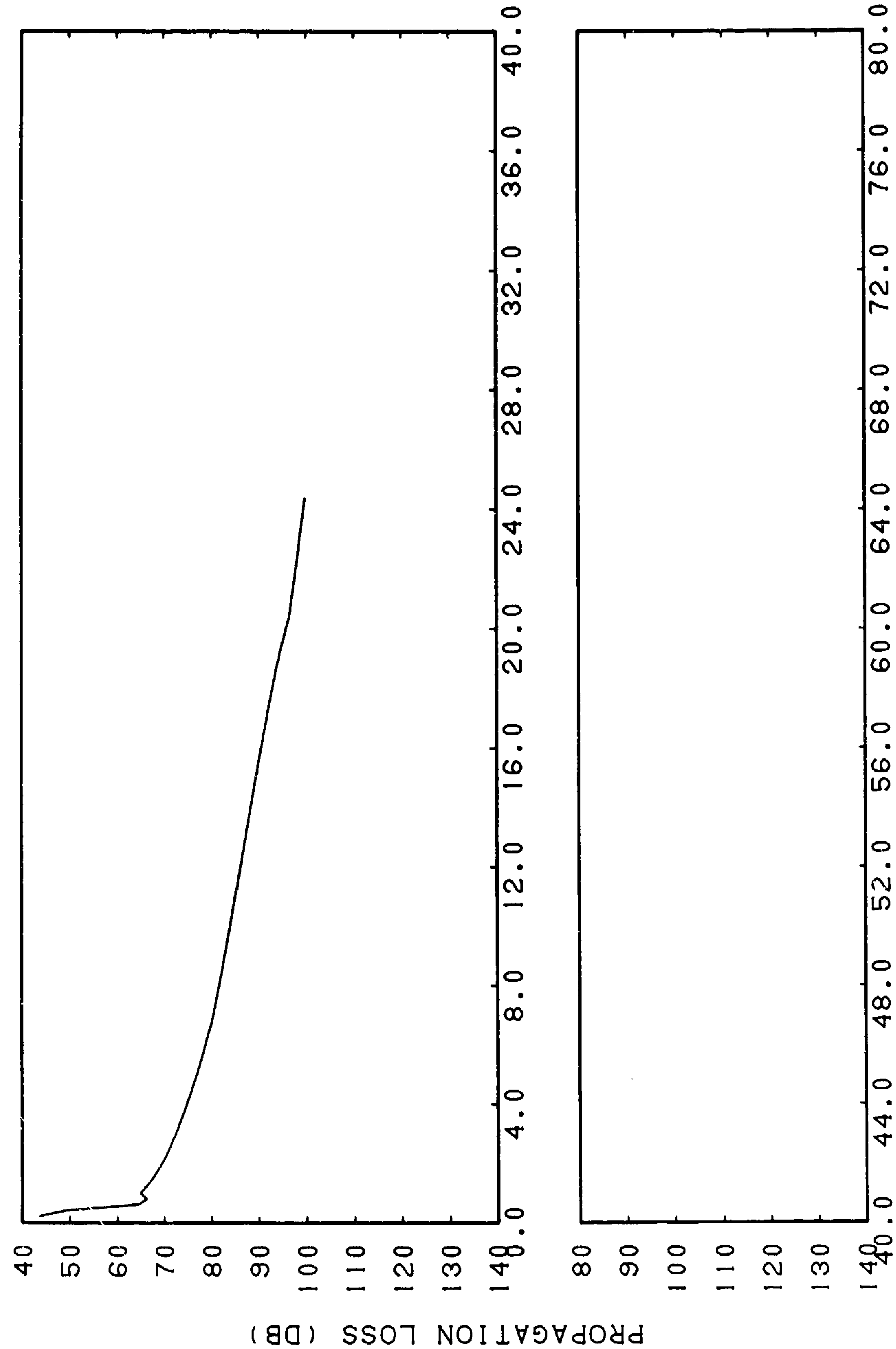
CONFIDENTIAL

(C) Figure IIA-[illegible]. FACT Incoherent, Frequency = 0.4 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 112 Meters



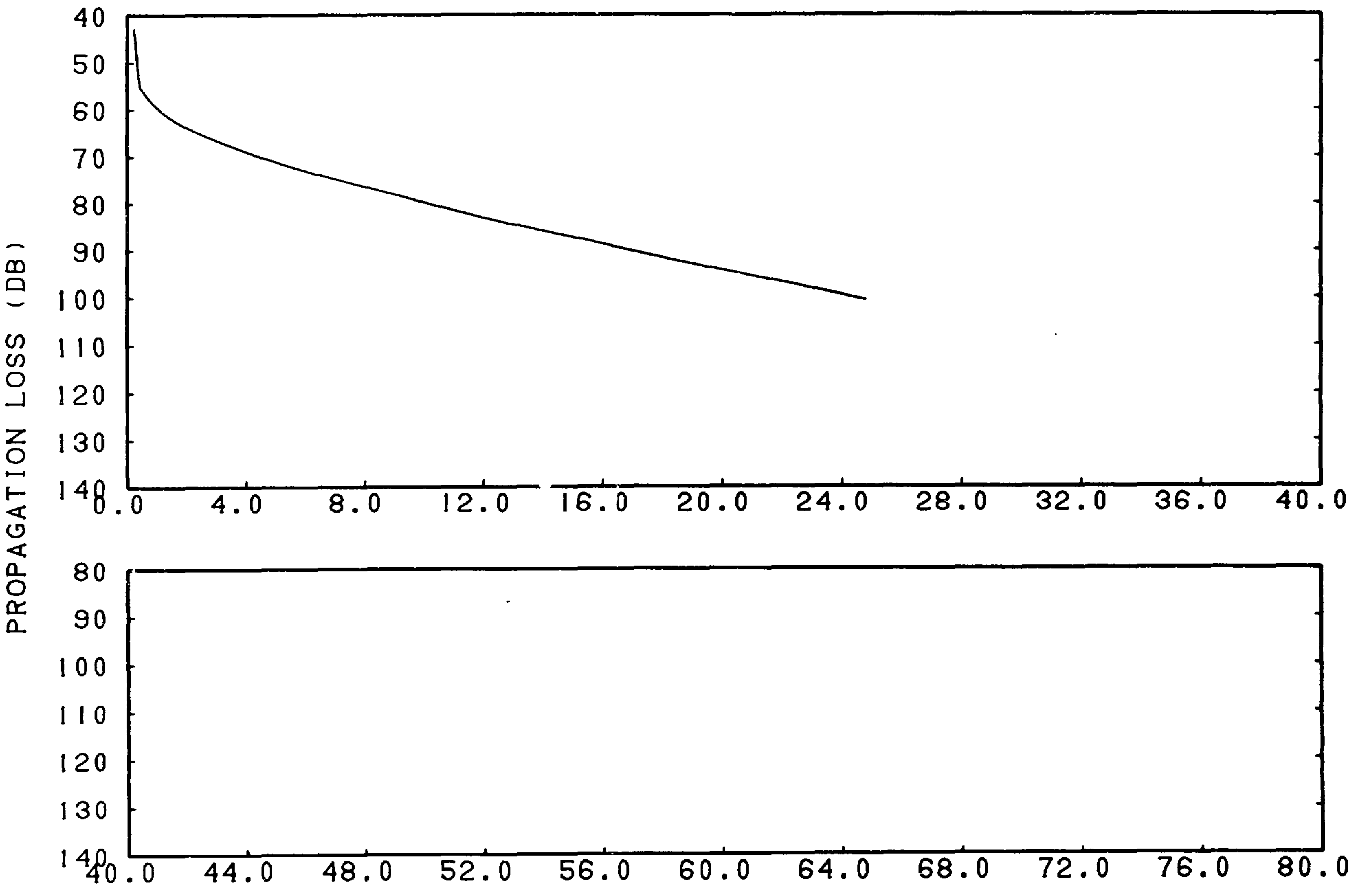
CONFIDENTIAL

(C) Figure IIA-54. FACT Incoherent, Frequency = 1.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 43 Meters



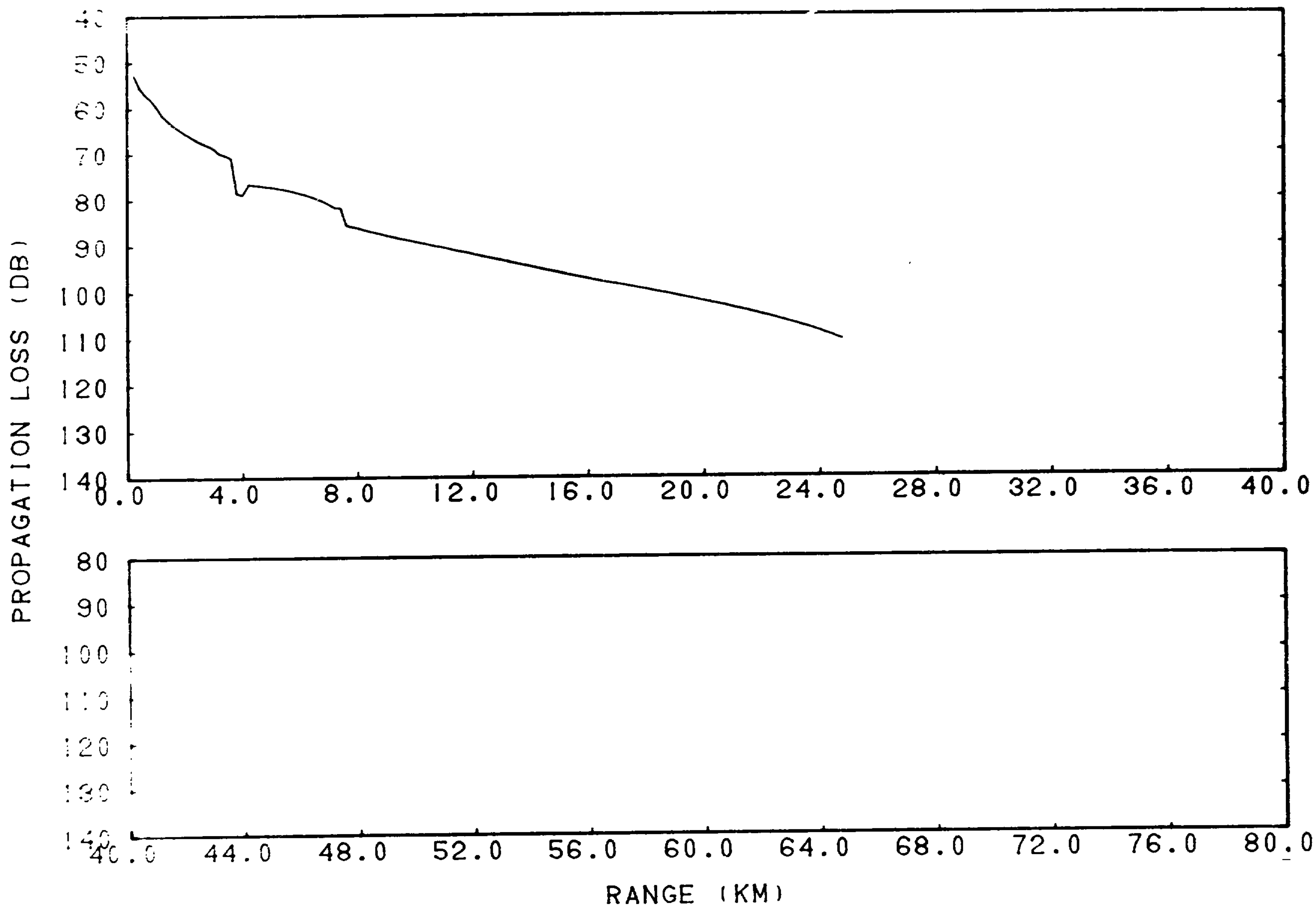
CONFIDENTIAL

(C) Figure IIA-55. FACT Incoherent, Frequency = 1.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 112 Meters



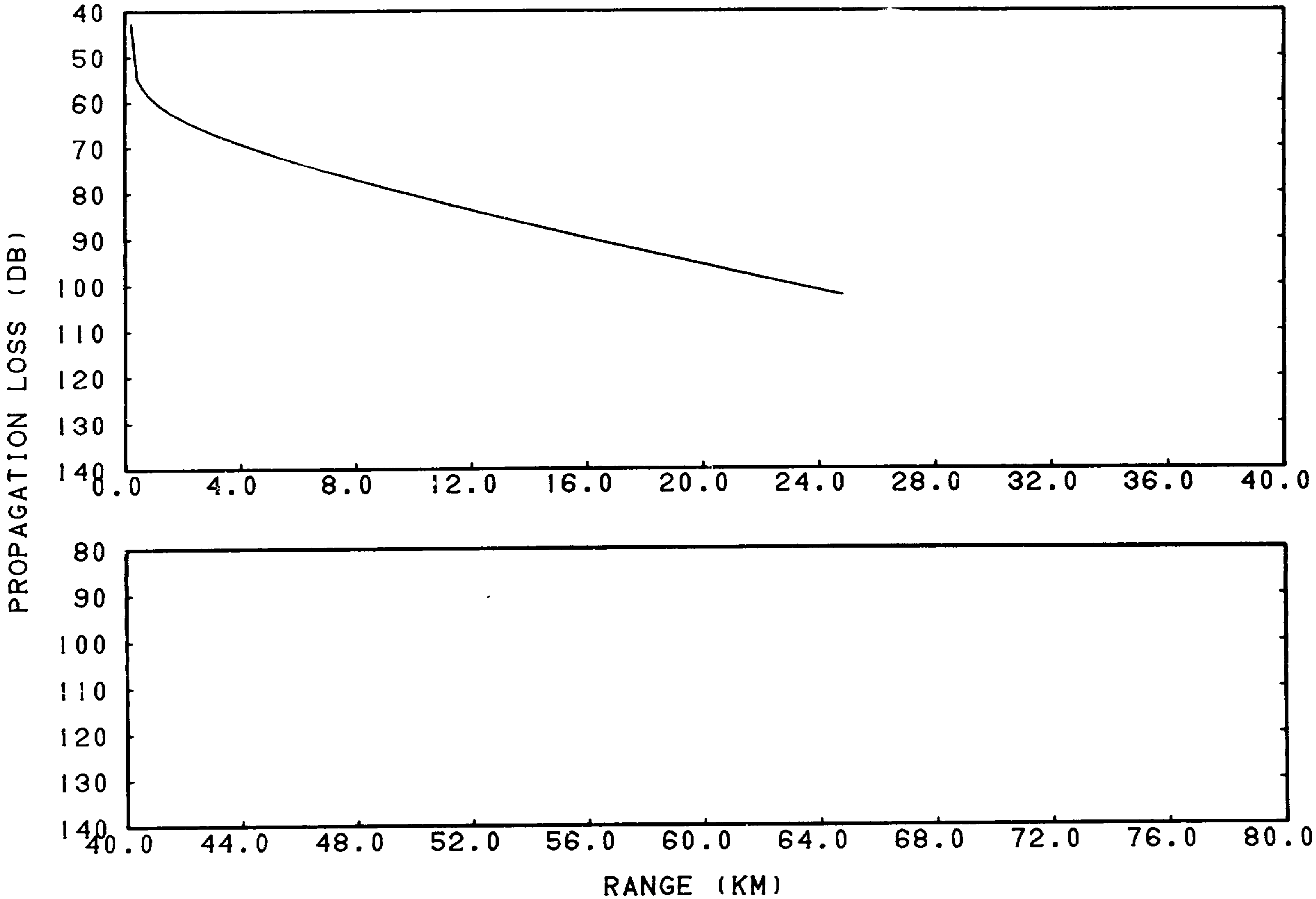
CONFIDENTIAL

(C) Figure IIA-56. FACT Incoherent, Frequency = 1.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 6 Meters



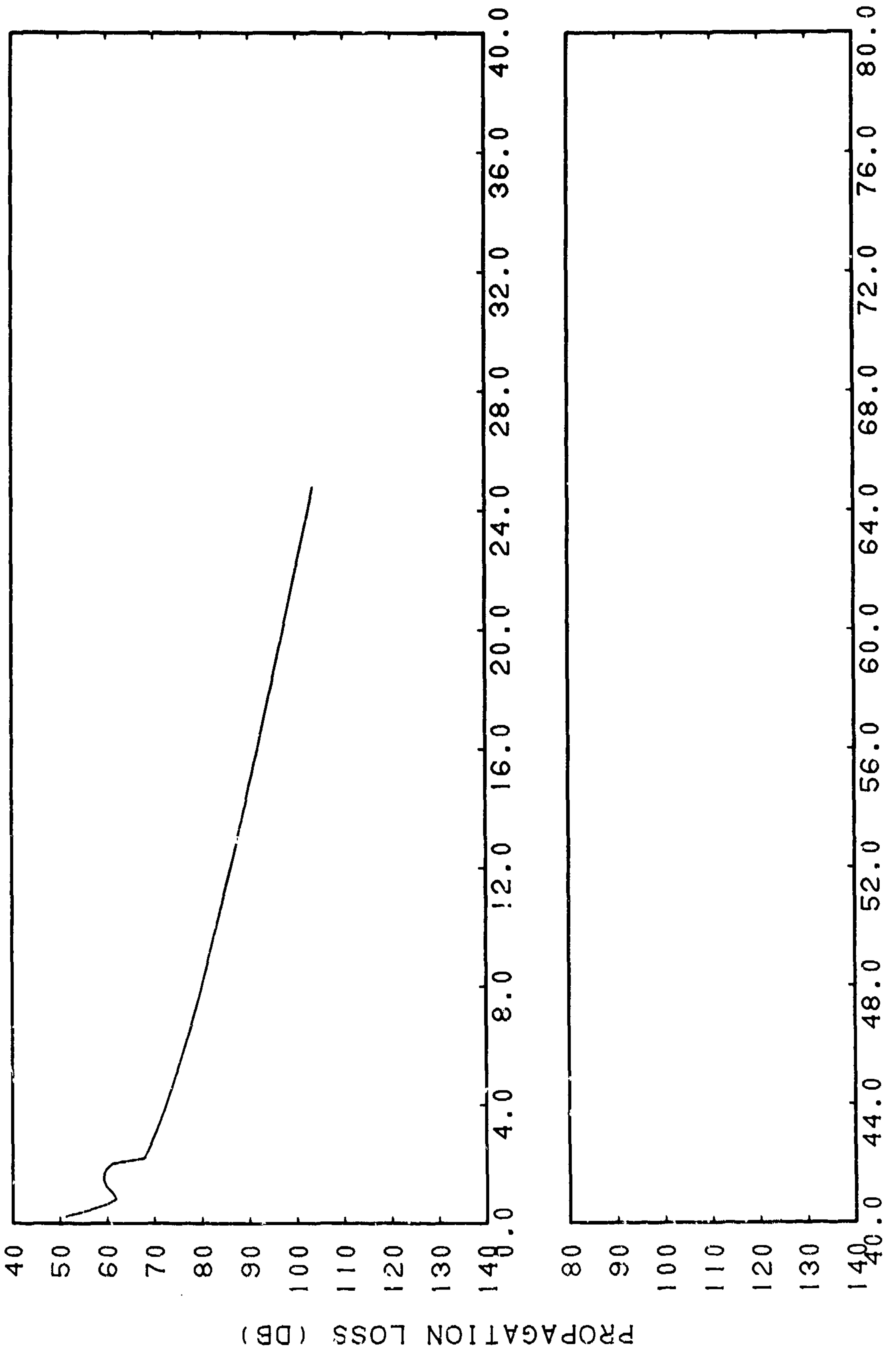
CONFIDENTIAL

(C) Figure IIA-57. FACT Incoherent, Frequency = 1.5 Kilohertz, Source Depth 41 Meters, Receiver Depth = 59 Meters



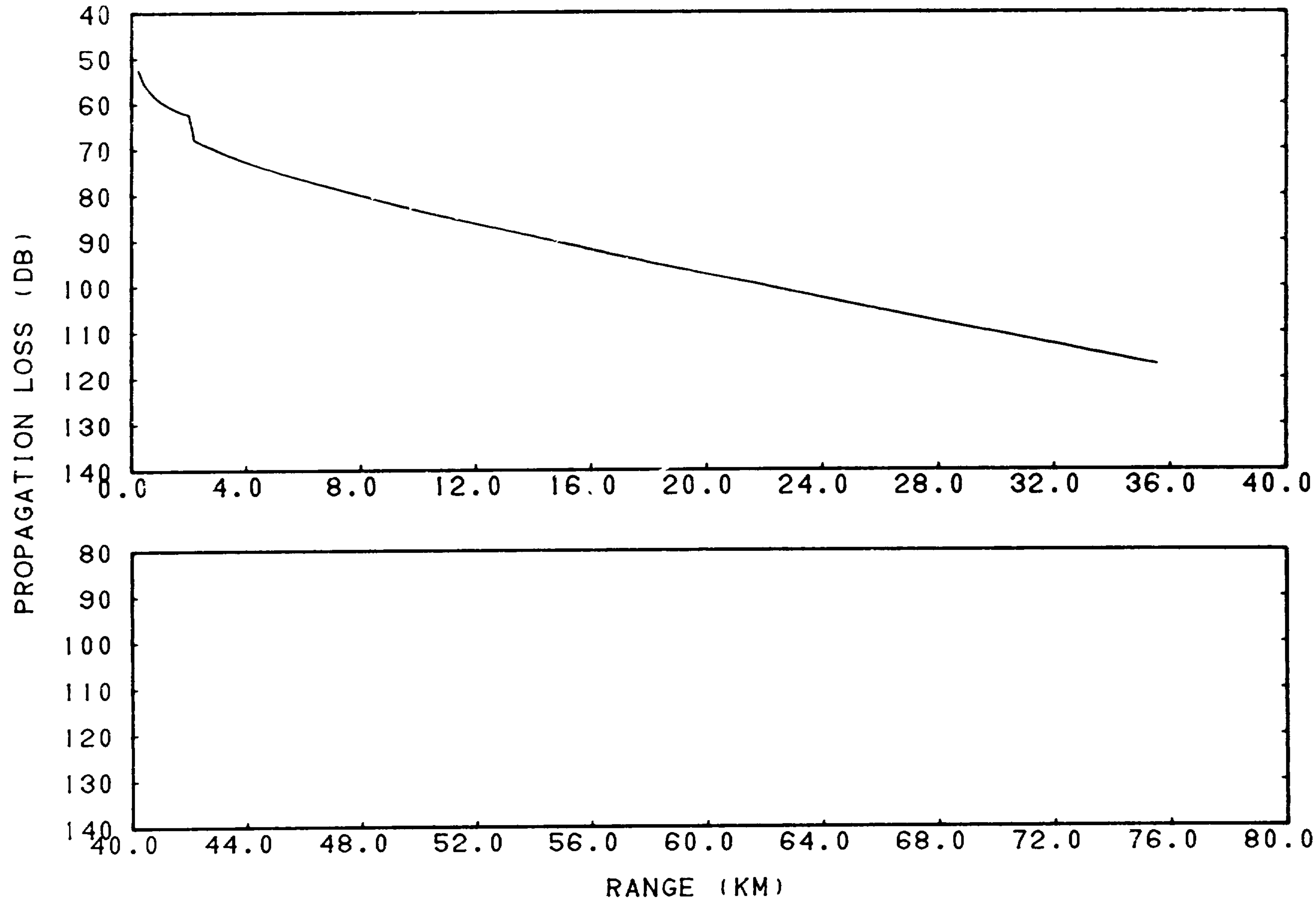
CONFIDENTIAL

(C) Figure IIA-58. FACT Incoherent, Frequency = 2.5 Kilohertz, Source Depth 41 Meters, Receiver Depth = 6 Meters



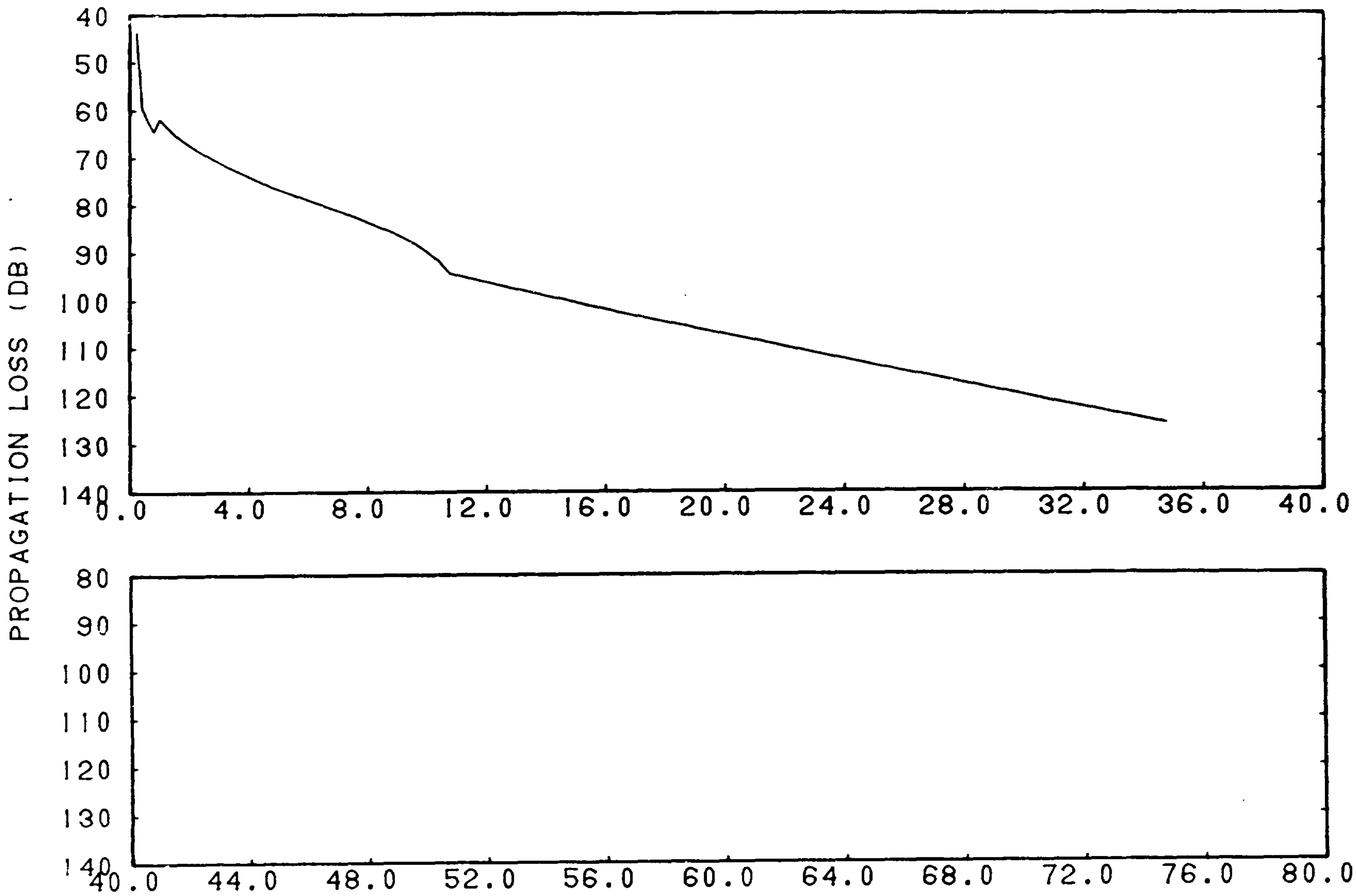
CONFIDENTIAL

(C) Figure IIA-59. FACT Incoherent, Frequency = 2.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 59 Meters



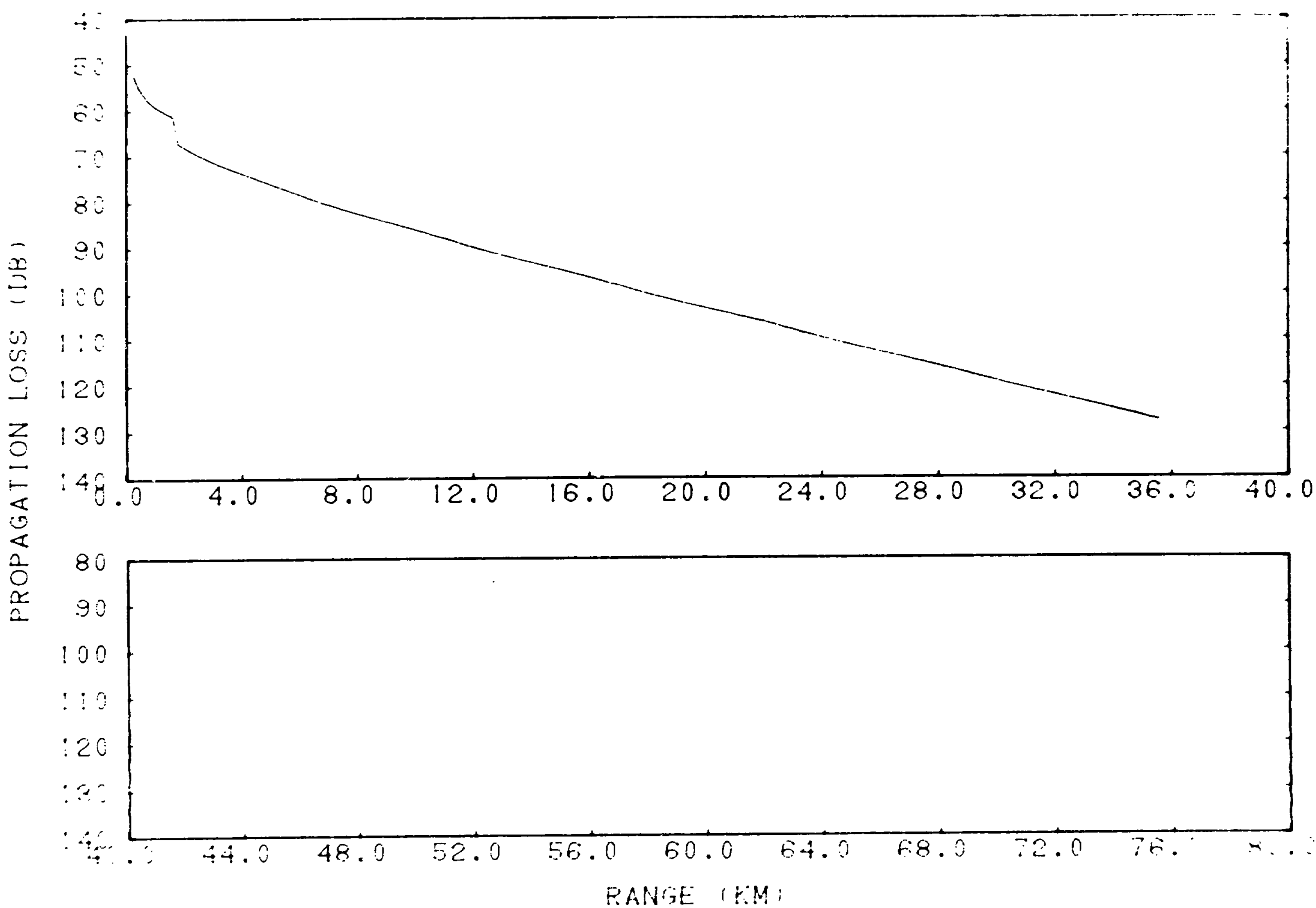
CONFIDENTIAL

(C) Figure IIA-60. FACT Incoherent, Frequency = 3.5 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 17 Meters



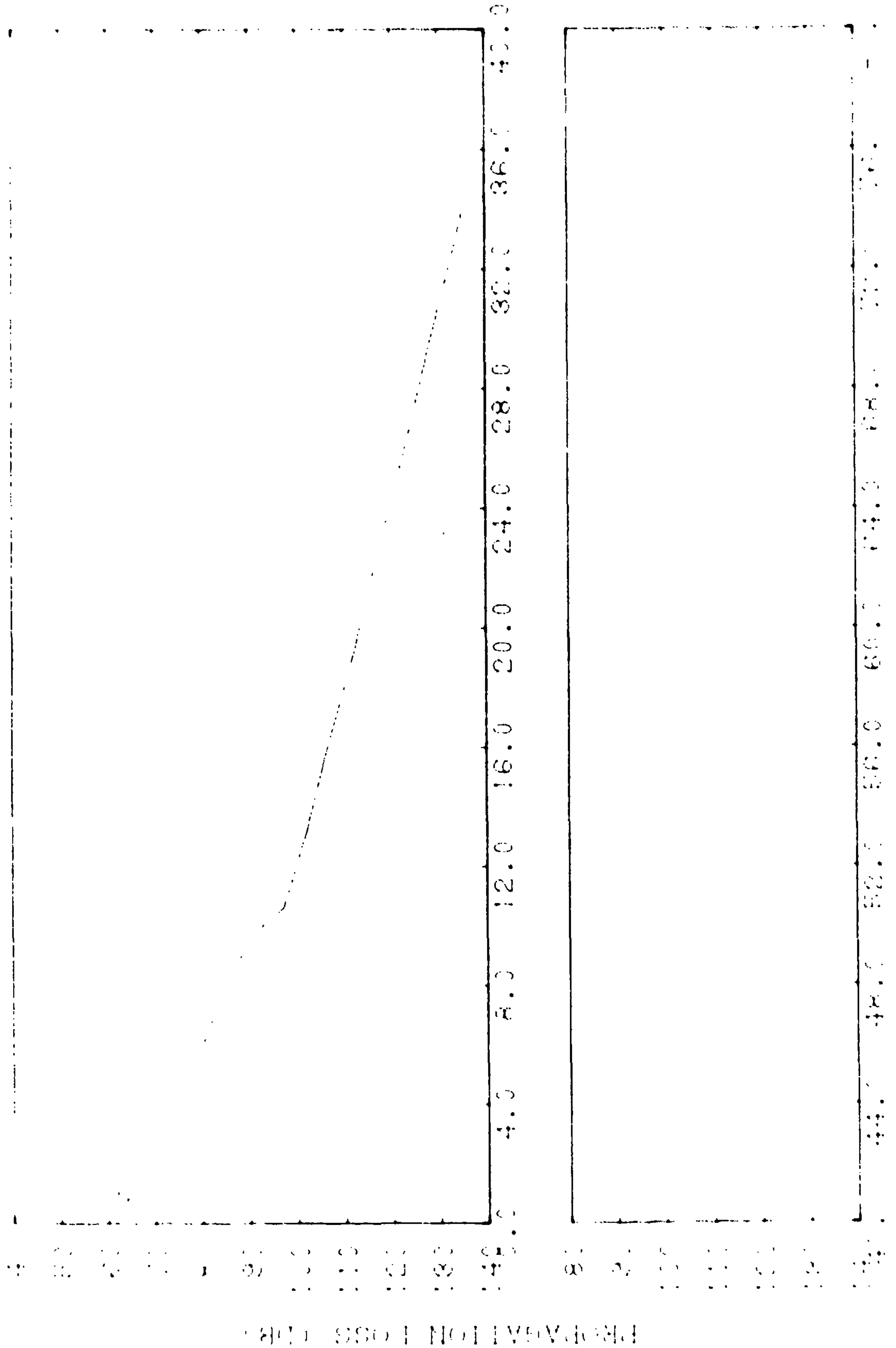
CONFIDENTIAL

(C) Figure IIA-61. FACT Incoherent, Frequency = 3.5 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 112 Meters



CONFIDENTIAL

(C) Figure IIA-62. FACT Incoherent, Frequency = 5.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 17 Meters



CONFIDENTIAL

(C) Figure IIA-63. FACT Incoherent, Frequency = 5.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 112 Meters

THIS

PAGE

INTENTIONALLY

LEFT

BLANK

Appendix IIB. Accuracy Assessment of FACT PL9D Compared to HAYS-MURPHY Mediterranean Experimental Data (U)

HAYS-MURPHY (U)

Environment (U)

(C) The Hays-Murphy data used here were collected in the Algiers-Provencal Basin of the Mediterranean Sea over a distance of 200 km of what is termed the St. Margarets run (Martin, 1981). The St. Margarets run was much longer but the flat bottom assumption of range independent propagation loss models was violated past 200 km. The sound speed profile is plotted in Figure IIB1. The profile is essentially bilinear with the minimum at 61 m. The critical depth is 1894 m indicating a depth excess of approximately 850 m.

(C) Two sets of bottom loss tables were used as input to the FACT PL9D model. The first is FACT's internal FNOC/NOO bottom loss found in subroutine BTMLOS and, in the six cases examined, an FNOC Type 3 bottom was found to pertain at the site of the receiver. The second set of bottom loss curves are the MGS curves found in Subroutine MGSBL in the RAYMODE X model, and for the Hays-Murphy cases, MGS Bottom Type 2 was used. These curves were input into FACT PL9D from an external table. The six cases of Hays-Murphy acoustic data cover four frequencies: 35, 67.5, 100, and 200 Hz. For the lowest three frequencies, a single bottom loss curve is found from each of the MGS and the FNOC sets of curves. The FNOC curve for 150 Hz and less is listed in Table IIB1; the MGS curve for 100 Hz and less is given in Table IIB3. The FNOC curve has a critical angle of 12°, 1 dB loss at 15° and 10 dB at normal incidence. In comparison, the RAYMODE based curve has a critical angle of 9 degrees, 1.6 dB loss at 15 degrees and 8 dB loss as normal incidence. The bottom loss curves for 200 Hz are given in Tables IIB2 and IIB4 for FACT and RAYMODE, respectively. From FACT, the bottom loss has a constant value of 3 dB at 14 degrees, 3.3 dB loss at 15 degrees, and 11 dB loss at normal incidence. From RAYMODE, the loss is 1.1 dB at 0 degrees, 2.7 dB at 15 degrees, and 8.3 dB at normal incidence.

Test Cases (U)

(C) Six test cases were chosen for experimental data/model comparison:

Case	Source Depth	Receiver Depth	Frequency (Hz)
I	24.4m (80 ft)	137.2m (450 ft)	35.0
II	24.4m (80 ft)	137.2m (450 ft)	67.5
III	24.4m (80 ft)	137.2m (450 ft)	100.0
IV	24.4m (80 ft)	137.2m (450 ft)	200.0
V	24.4m (80 ft)	106.7m (350 ft)	35.0
VI	25.5m (80 ft)	106.7m (350 ft)	100.0

CONFIDENTIAL

(C) The experimental data for the six cases is given in Figures IIB2-IIB7. The experimental data for these cases show a frequency dependence whereby in going from 67.5 to 100 to 200 Hz the propagation loss increases by approximately 6 dB. There does not seem to be a significant frequency dependence in going from 35 to 67.5 Hz. In comparing Cases I with V and case III with VI there is not a significant receiver depth dependence over the 30.5 m depth difference. In all cases the data is free of convergence zone structure but shows fluctuations of 4-5 dB in the first 100 km modulating an overall decrease of about 10 dB and 2-5 dB fluctuations modulating an overall decrease of 2-5 dB in the second 100 km. The Hays-Murphy data results from 1/3-octave analysis of explosive detonations. The frequencies given are the geometric mean frequencies of the 1/3-octave bands.

Accuracy Assessment Results (U)

(C) FACT PL9D results for the coherent option show a Lloyd Mirror interference effect to about 20 km at 35 Hz and interference with 40 km periodicity to 160 km at 200 Hz. Overall, the span of values covered in ea 100 km interval is similar to that of the experimental data. The semi-coherent FACT results are somewhat smoother but reveal the same basic pattern. In the incoherent results the Lloyd Mirror pattern is suppressed but the longer periodicity (approximately 40 km) is still present and in the context of this data represents downward steps of 5-12 dB for the first step and 3-10 dB for the second, the largest steps at 200 Hz and the smallest at 35 Hz. The overall trend, however, remains a 10 dB decrease in the first 100 km and a 2-5 dB decrease in the second 100 km interval.

(C) The accuracy assessment procedures applied to the FACT outputs and the experimental data are described in section 1.1 of this volume and in greater detail in section 5 of Volume I of this series. For these cases, no significant propagation loss features are evident in the experimental data and for calculation of statistics of differences from model results, arbitrary intervals of 0-25 km, 25-50 km, and 50-200 km were selected. The means and standard deviations of differences between Hays-Murphy experimental data and FACT PL9D model outputs are found in Tables IIB5a-c for the coherent, semi-coherent, and incoherent results, respectively where the FNOC bottom loss was used. Similar results in which FACT PL9D used the MGS bottom loss are given in Table IIB6a-c. The following figures were produced for each case:

(1) FACT PL9D using the coherent option, (2) this coherent result smoothed by a running average of 3 points (i.e., a 2 km window), (3) the smoothed coherent result subtracted from Hays-Murphy experimental data, (4) FACT PL9D output using the semi-coherent option, (5) the semi-coherent result subtracted from Hays-Murphy data, (6) FACT PL9D output using the incoherent option, and (7) the incoherent result subtracted from Hays-Murphy data. These seven curves are given first for all cases where FACT PL9D was run with its own internal bottom loss and then for FACT PL9D run using the MGS bottom loss curves from RAYMODE X. The plots are given as follows:

Case	FACT (i.e., FNOC) Bottom	RAYMODE (i.e., MGS) Bottom
I	Figure IIB8-IIB14	Figure IIB50-IIB56
II	Figure IIB15-IIB21	Figure IIB57-IIB63
III	Figure IIB22-IIB28	Figure IIB64-IIB70
IV	Figure IIB29-IIB35	Figure IIB71-IIB77
V	Figure IIB36-IIB42	Figure IIB78-IIB84
VI	Figure IIB43-IIB49	Figure IIB85-IIB91

CONFIDENTIAL

(C) In examining the means and standard deviations of the difference between Hays-Murphy data and FACT PL9D outputs, the following conclusions may be drawn:

(1) In all cases the model exhibits greater loss than does the experimental data (indicating that the model prediction is overly pessimistic). Bottom parameter measurements near the site (DiNapoli et al., 1972), when converted to bottom loss via a Rayleigh model which includes attenuation in the bottom, result in a bottom loss curve with a critical angle of 20° and a normal incidence loss of 5.9 dB. This is clearly lower than either the FACT or RAYMODE loss and would likely eliminate much of the off within the first region (i.e., to 25 km).

(2) In the 0 to 25 km interval the standard deviations range from 4.0 to 6.3 dB for coherent predictions, 4.0 to 7.9 dB for semi-coherent results, and 1.6 to 2.3 dB for incoherent results. The low standard deviation of differences for the incoherent results is due to their lack of Lloyd Mirror interference, a lack also noted in the Hays-Murphy data.

(3) Aside from the first interval, standard deviations of differences are in the 1-3 dB range.

(4) There is no significant difference between use of the FACT bottom loss or RAYMODE bottom loss.

(5) The agreement between model results and Hays-Murphy data is best at 200 Hz and significantly better than results for the other three frequencies. We recall that the three lower frequencies all used the same bottom loss table and that the difference in bottom loss probably accounts for the improved result at 200 Hz.

Note: This applies only to the first bottom bounce region (i.e., to 25 km) beyond which bottom bounce is not a significant contributor.

(C) The figure of merit (FOM) vs. detection range analysis for the six Hays-Murphy cases are given in Table IIB7 when FACT uses its own bottom loss and Table IIB8 when FACT used RAYMODE's bottom loss. For an FOM of 75 dB, the FACT PL9D model consistently predicts maximum detection ranges of 1-2 km, regardless of coherence option. The Hays-Murphy data, however, show continuous coverage to ranges between 17 and 42 km and partial coverage to between 37.5 and 47 km where, in most cases, the coverage is zonal with coverage between 10 and 90% depending on the case under examination. For an FOM of 80 dB, the range of continuous coverage for the Hays-Murphy data was between 42 and 55 km. The corresponding range for FACT was 1.5 to 20 km. The partial coverage ranges for Hays-Murphy data varied from 52-115 km compared to 24-47.5 km for FACT. For an FOM of 85 dB, Hays-Murphy continuous coverage ranges from 54 to >200 km; corresponding values for FACT were 1.5 to 47.5 km. Partial coverage for Hays-Murphy data ranged from 127 to >200 km, whereas for FACT the range of values was 49 to 81.5 km. For an FOM of 90 dB, Hays-Murphy data indicates continuous detection coverage over the entire 200 km interval in all cases. In contrast, FACT predicted continuous coverage ranges from 2 to >200 km and partial coverage from 121 to >200 km. For percentages associated with the partial coverages at the various FOMs and for greater detail on a case-by-case basis, the reader is referred to Tables IIB7 and IIB8.

(C) General conclusions based on comparison of FACT PL9D outputs with Hays-Murphy experimental data follow:

(1) Significant differences in mean levels were primarily responsible for pessimistic detection range predictions by the model. These differences appear to be attributable to the bottom loss inputs within the first 25 km. Beyond this range differences are as great and unexplained, but bottom loss is not a factor. It is to be noted that for this scenario, FACT and RAYMODE bottom loss inputs led to essentially the same results.

(2) Large differences in the first 25 km were caused by semi-coherent and coherent predictions of Lloyd Mirror interference patterns absent in the Hays-Murphy data (possibly due to the broadband (i.e., one-third octave) analysis of same). Once again, this disparity is not felt to represent an error in the model.

References (U)

1. DiNapoli, M. R. Powers, R. C. Jennings and D. J. Ryan (1972). Acoustic Model for an FBM Sonar Trainger: Part I-Low Frequency Acoustic Propagation (U). NUSC Technical Memorandum No. PA4-02-72. CONFIDENTIAL.

2. Martin, R. L. et al. The Acoustic Model Evaluation Committee (AMEC) Reports. Volume IA. Summary of Range Independent Environmental Acoustic Propagation Loss Data Sets (U). Naval Ocean Research and Development Activity Report No. 34. CONFIDENTIAL.

(U) Table IIB-1. Bottom Loss in dB Versus Grazing Angle in Degrees. FNOC Bottom Type 3. Frequency $\leq$ 150 Hertz.

Θ	BL
0	0.0
11	0.0
20	3.0
25	4.4
35	6.7
45	8.5
56	10.0
90	10.0

UNCLASSIFIED

(U) Table IIB-2. Bottom Loss in dB Versus Grazing Angle in Degrees. FNOC Bottom Type 3. Frequency = 200 Hertz.

Θ	BL
0	3.0
13	3.0
20	5.3
35	8.7
45	10.3
53	11.0
90	11.0

UNCLASSIFIED

(U) Table IIB-3. Bottom Loss in dB Versus Grazing Angle in Degrees. MGS Bottom Type 2. Frequency ≤ 100 Hertz..

Θ	BL	Θ	BL	Θ	BL	Θ	BL	Θ	BL	Θ	BL
0	0.00	15	1.92	30	5.23	45	7.25	60	8.28	75	8.54
1	0.00	16	2.19	31	5.40	46	7.34	61	8.32	76	8.54
2	0.00	17	2.45	32	5.57	47	7.44	62	8.36	77	8.52
3	0.00	18	2.70	33	5.73	48	7.53	63	8.39	78	8.51
4	0.00	19	2.95	34	5.88	49	7.61	64	8.42	79	8.49
5	0.00	20	3.19	35	6.03	50	7.69	65	8.45	80	8.48
6	0.00	21	3.42	36	6.17	51	7.77	66	8.47	81	8.45
7	0.00	22	3.65	37	6.31	52	7.84	67	8.49	82	8.43
8	0.00	23	3.87	38	6.45	53	7.91	68	8.51	83	8.40
9	0.14	24	4.08	39	6.57	54	7.97	69	8.52	84	8.37
10	0.46	25	4.29	40	6.70	55	8.03	70	3.53	85	8.33
11	0.77	26	4.49	41	6.82	56	8.09	71	8.54	86	8.30
12	1.07	27	4.68	42	6.93	57	8.14	72	8.55	87	8.26
13	1.36	28	4.87	43	7.04	58	8.19	73	8.55	88	8.21
14	1.64	29	5.05	44	7.15	59	8.24	74	8.55	89	8.17

UNCLASSIFIED

(U) Table IIB-4. Bottom Loss in dB Versus Grazing Angle in Degrees.
MGS Bottom Type 2. Frequency = 200 Hertz.

Θ	BL	Θ	BL	Θ	BL	Θ	BL	Θ	BL	Θ	BL
0	1.08	15	2.88	30	5.51	45	7.16	60	8.08	75	8.43
1	1.12	16	3.09	31	5.65	46	7.24	61	8.12	76	8.43
2	1.15	17	3.30	32	5.78	47	7.32	62	8.16	77	8.43
3	1.19	18	3.50	33	5.91	48	7.40	63	8.19	78	8.43
4	1.22	19	3.69	34	6.03	49	7.47	64	8.22	79	8.43
5	1.26	20	3.88	35	6.15	50	7.54	65	8.25	80	8.43
6	1.29	21	4.07	36	6.27	51	7.61	66	8.28	81	8.42
7	1.32	22	4.25	37	6.38	52	7.67	67	8.31	82	8.41
8	1.35	23	4.42	38	6.49	53	7.73	68	8.33	83	8.40
9	1.48	24	4.59	39	6.60	54	7.79	69	8.35	84	8.39
10	1.73	25	4.76	40	6.70	55	7.84	70	8.37	85	8.38
11	1.97	26	4.92	41	6.80	56	7.90	71	8.38	86	8.36
12	2.21	27	5.07	42	6.90	57	7.95	72	8.40	87	8.34
13	2.44	28	5.22	43	6.99	58	7.99	73	8.41	88	8.32
14	2.66	29	5.37	44	7.08	59	8.04	74	8.42	89	8.30

UNCLASSIFIED

(C) Table IIB-5a. Means (μ) and Standard Deviations (σ) in dB of Differences Between Hays-Murphy Experimental Data and FACT PL9D Coherent Model Output.[1] Bottom Loss = FNOC Type 3.

Case	Frequency (Hz)	Source Depth (ft)	Receiver Depth (ft)	0-25 km		25-50 km		50-200 km	
				μ	σ	μ	σ	μ	σ
I	35.0	80	450	-11.1	4.5	-6.7	2.6	-6.0	1.8
II	67.5	80	450	-12.2	6.3	-6.1	3.3	-5.9	1.3
III	100.0	80	450	-10.6	4.9	-4.3	3.2	-4.3	1.5
IV	200.0	80	450	-7.5	4.1	-3.4	3.0	-3.0	2.3
V	35.0	80	350	-9.0	6.3	-6.6	1.7	-5.3	1.6
VI	100.0	80	350	-9.2	4.6	-3.9	2.8	-2.9	1.7

1. Smoothed by application of a 2 kilometer window moving average.

CONFIDENTIAL

(C) Table IIB-5b. Means (μ) and Standard Deviations (σ) in dB of Differences Between Hays-Murphy Experimental Data and FACT PL9D Semicoherent Model Output. Bottom Loss = FNOC Type 3.

Case	Frequency (Hz)	Source Depth (ft)	Receiver Depth (ft)	0-25 km		25-50 km		50-200 km	
				μ	σ	μ	σ	μ	σ
I	35.0	80	450	-11.0	5.5	-6.7	2.6	-6.0	1.8
II	67.5	80	450	-9.9	6.0	-5.7	3.0	-5.9	1.3
III	100.0	80	450	-9.2	5.4	-4.4	3.2	-4.3	1.5
IV	200.0	80	450	-5.9	4.5	-3.0	2.4	-2.9	2.3
V	35.0	80	350	-9.0	7.9	-6.6	1.6	-5.3	1.6
VI	100.0	80	350	-8.1	5.8	-3.5	2.4	-2.9	1.7

CONFIDENTIAL

(C) Table IIB-5c. Means (μ) and Standard Deviations (σ) in dB of Differences Between Hays-Murphy Experimental Data and FACT PL9D Incoherent Model Output. Bottom Loss = FNOC Type 3.

Case	Frequency (Hz)	Source Depth (ft)	Receiver Depth (ft)	0-25 km		25-50 km		50-200 km	
				μ	σ	μ	σ	μ	σ
I	35.0	80	450	-9.5	2.2	-7.0	2.6	-6.4	1.8
II	67.5	80	450	-8.8	1.8	-7.1	1.8	-7.1	1.2
III	100.0	80	450	-6.7	2.3	-4.6	2.2	-4.6	1.5
IV	200.0	80	450	-4.9	1.8	-2.1	3.4	-2.6	2.4
V	35.0	80	350	-7.9	1.3	-6.5	1.7	-6.0	1.7
VI	100.0	80	350	-5.6	2.2	-3.5	2.2	-3.3	1.7

CONFIDENTIAL

(C) Table IIB-6a. Means (μ) and Standard Deviations (σ) in dB of Differences Between Hays-Murphy Experimental Data and FACT PL9D Coherent Model Output.[1] Bottom Loss = MGS Type 2.

Case	Frequency (Hz)	Source Depth (ft)	Receiver Depth (ft)	0-25 km		25-50 km		50-200 km	
				μ	σ	μ	σ	μ	σ
I	35.0	80	450	-10.7	4.0	-7.0	2.6	-6.3	1.8
II	67.5	80	450	-11.7	5.5	-6.4	3.1	-6.9	1.3
III	100.0	80	450	-10.0	4.9	-4.4	3.2	-4.4	1.5
IV	200.0	80	450	-5.4	4.1	-2.3	2.8	-2.4	2.2
V	35.0	80	350	-8.7	5.6	-7.1	1.7	-6.3	1.7
VI	100.0	80	350	-8.6	4.5	-3.9	2.9	-2.9	1.7

1. Smoothed by application of a 2 kilometer window moving average.

CONFIDENTIAL

(C) Table IIB-6b. Means (μ) and Standard Deviations (σ) in dB of Differences Between Hays-Murphy Experimental Data and FACT PL9D Semicoherent Model Output. Bottom Loss = MGS Type 2.

Case	Frequency (Hz)	Source Depth (ft)	Receiver Depth (ft)	0-25 km		25-50 km		50-200 km	
				μ	σ	μ	σ	μ	σ
I	35.0	80	450	-10.7	5.1	-6.9	2.6	-6.3	1.8
II	67.5	80	450	-9.6	5.4	-6.0	2.9	-6.9	1.3
III	100.0	80	450	-8.7	5.1	-4.5	3.2	-4.4	1.5
IV	200.0	80	450	-3.7	4.0	-1.9	2.2	-2.4	2.1
V	35.0	80	350	-8.7	7.2	-7.1	1.7	-6.3	1.7
VI	100.0	80	350	-7.7	5.8	-3.5	2.5	-2.9	1.7

CONFIDENTIAL

(C) Table IIB-6c. Means (μ) and Standard Deviations (σ) in dB of Differences Between Hays-Murphy Experimental Data and FACT PL9D Incoherent Model Output. Bottom Loss = MGS Type 2.

Case	Frequency (Hz)	Source Depth (ft)	Receiver Depth (ft)	0-25 km		25-50 km		50-200 km	
				μ	σ	μ	σ	μ	σ
I	35.0	80	450	-9.3	2.3	-7.3	2.6	-6.8	1.8
II	67.5	80	450	-8.6	1.7	-7.4	1.7	-7.6	1.3
III	100.0	80	450	-6.5	2.0	-4.9	2.2	-5.0	1.6
IV	200.0	80	450	-3.0	2.1	-1.4	3.0	-2.2	2.1
V	35.0	80	350	-7.7	1.6	-6.7	1.7	-6.4	1.8
VI	100.0	80	350	-5.4	2.0	-3.7	2.1	-3.7	1.8

CONFIDENTIAL

(C) Table IIB-7a. Detection Range in Kilometers as a Function of Figure of Merit (FOM) in dB for Hays-Murphy Mediterranean Experimental Data and FACT PL9D Model Predictions
Case I:
(Source Depth = 80 ft., Receiver Depth = 450 ft., Frequency = 35 Hz).
Bottom Loss: FNOC Type 3.

Data Set	FOM	R_c [1]	Range > R_c
Hays-Murphy	75	25.5	ZDC[2] 60%, 25.5-44 km
FACT Coherent	75	1.0	
FACT Semicoherent	75	1.5	
FACT Incoherent	75	2.0	
Hays-Murphy	80	54.5	ZDC 50%, 54.5-93 km
FACT Coherent	80	1.0	ZDC 60%, 1-32 km
FACT Semicoherent	80	1.5	ZDC 50%, 1.5-32 km
FACT Incoherent	80	21.0	
Hays-Murphy	85	130.5	ZDC 50%, 130.5-172.5 km
FACT Coherent	85	2.0	100% coverage, 4-52 km
FACT Semicoherent	85	1.5	ZDC 85%, 1.5-48 km
FACT Incoherent	85	47.5	
Hays-Murphy	90	> 200.0	
FACT Coherent	90	160.5	
FACT Semicoherent	90	162.0	
FACT Incoherent	90	161.0	

1. R_c = Range to which detection coverage is continuous.

2. ZDC = Zonal Detection coverage in percentage of the indicated range interval for which detection is possible.

CONFIDENTIAL

(C) Table IIB-7b. Detection Range in Kilometers as a Function of Figure of Merit (FOM) in dB for Hays-Murphy Mediterranean Experimental Data and FACT PL9D Model Predictions
Case II:
(Source Depth = 80 ft., Receiver Depth = 450 ft., Frequency = 67.5 Hz).
Bottom Loss: FNOC Type 3.

Data Set	FOM	R_c[1]	Range > R_c
Hays-Murphy	75	42.5	
FACT Coherent	75	1.5	
FACT Semicoherent	75	1.5	
FACT Incoherent	75	1.5	
Hays-Murphy	80	54.0	ZDC[2] 50%, 54-113 km
FACT Coherent	80	2.0	ZDC 35%, 2-47 km
FACT Semicoherent	80	1.5	ZDC 40%, 1.5-47.5 km
FACT Incoherent	80	19.0	100% coverage, 34.5-41.5 km
Hays-Murphy	85	>200.0	Except for a few dropouts of ≲ 1 km
FACT Coherent	85	2.5	ZDC 80%, 2.5-79 km
FACT Semicoherent	85	1.5	ZDC 80%, 1.5-80.5 km
FACT Incoherent	85	47.5	100% coverage, 66.5-80 km
Hays-Murphy	90	> 200.0	
FACT Coherent	90	8.0	100% coverage to > 200 km except for 54-56 km
FACT Semicoherent	90	> 200.0	
FACT Incoherent	90	123.0	100% coverage, 142-160 km

1. R_c = Range to which detection coverage is continuous.

2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval for which detection is possible.

CONFIDENTIAL

(C) Table IIB-7c. Detection Range in Kilometers as a Function of Figure of Merit (FOM) in dB for Hays-Murphy Mediterranean Experimental Data and FACT PL9D Model Predictions
C·se III:
(Source Depth = 80 ft., Receive ·epth = 450 ft., Frequency = 100 Hz).
Bottom Los·: FNOC Type 3.

Data Set	FOM	R_c[1]	Range > R_c
Hays-Murphy	75	17.5	ZDC[2] 60%, 17.5-42 km
FACT Coherent	75	1.0	
FACT Semicoherent	75	1.5	
FACT Incoherent	75	1.5	
Hays-Murphy	80	43.5	ZDC 20%, 43.5-84 km
FACT Coherent	80	1.5	ZDC 5%, 1.5-25 km; 100% coverage, 25-44.5 km
FACT Semicoherent	80	1.5	ZDC 40%, 1.5-44 km
FACT Incoherent	80	14.0	100% coverage, 32-41.5 km
Hays-Murphy	85	127.5	ZDC 70%, 127.5-190 km
FACT Coherent	85	2.0	ZDC 75%, 2-81.5 km
FACT Semicoherent	85	1.5	ZDC 75%, 1.5-81 km
FACT Incoherent	85	47.5	100% coverage, 66.5-80 km
Hays-Murphy	90	> 200.0	
FACT Coherent	90	15.0	100% coverage except 15-18, 48-49, 161.5-180 and 190-199 km
FACT Semicoherent	90	1.5	100% (except three 1 km dropouts) to 162 km 100% coverage, 162-181 and 191-100 km
FACT Incoherent	90	123.5	100% coverage, 139-161.5 and 181-193.5 km

1. R_c = Range to which detection coverage is continuous.

2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval for which detection is possible.

(C) Table IIB-7d. Detection Range in Kilometers as a Function of Figure of Merit (FOM) in dB for Hays-Murphy Mediterranean Experimental Data and FACT PL9D Model Predictions
Case IV:
(Source Depth = 80 ft., Receiver Depth = 450 ft., Frequency = 200 Hz).
Bottom Loss: FNOC Type 3.

Data Set	FOM	R_c [1]	Range > R_c
Hays-Murphy	75	21.5	ZDC[2] 90%, 21.5-37.5 km
FACT Coherent	75	1.5	
FACT Semicoherent	75	1.5	
FACT Incoherent	75	1.5	
Hays-Murphy	80	42.5	ZDC 50%, 42.5-95 km
FACT Coherent	80	2.0	100% coverage, 32-39 km
FACT Semicoherent	80	1.5	ZDC 10%, 1.5-39 km
FACT Incoherent	80	2.0	100% coverage, 32.5-40.5 km
Hays-Murphy	85	194.0	
FACT Coherent	85	8.0	ZDC 50%, 8-77 km
FACT Semicoherent	85	2.0	ZDC 50%, 2-78 km
FACT Incoherent	85	47.5	100% coverage, 68-76.5 km
Hays-Murphy	90	>200.0	
FACT Coherent	90	44.0	100% coverage, 49-52, 57.5-81, 98-119.5 km
FACT Semicoherent	90	2.0	ZDC 75%, 2-121 km
FACT Incoherent	90	48.0	100% coverage, 57-62, 93-120, and 133-148 km

1. R_c = Range to which detection coverage is continuous.

2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval for which detection is possible.

CONFIDENTIAL

(C) Table IIB-7e. Detection Range in Kilometers as a Function of Figure of Merit (FOM) in dB for Hays-Murphy Mediterranean Experimental Data and FACT PL9D Model Predictions
Case V:
(Source Depth = 80 ft., Receiver Depth = 350 ft., Frequency = 35 Hz).
Bottom Loss: FNOC Type 3.

Data Set	FOM	R_c [1]	Range > R_c
Hays-Murphy	75	25.5	ZDC[2] 50%, 25.5-47 km
FACT Coherent	75	1.5	
FACT Semicoherent	75	1.5	
FACT Incoherent	75	2.0	
Hays-Murphy	80	55.0	ZDC 40%, 55-93 km
FACT Coherent	80	2.0	ZDC 40%, 2-39 km
FACT Semicoherent	80	1.5	ZDC 50%, 1.5-39 km
FACT Incoherent	80	20.0	
Hays-Murphy	85	118.0	ZDC 50%, 118-188 km
FACT Coherent	85	2.0	ZDC 95%, 2-78.5 km
FACT Semicoherent	85	1.5	ZDC 40%, 1.5-12 km; 100% coverage, 12-81 km
FACT Incoherent	85	48.0	
Hays-Murphy	90	> 200.0	
FACT Coherent	90	132.5	100% coverage, 143-157.5 km
FACT Semicoherent	90	2.0	100% coverage, 135-142 and 160->200 km
FACT Incoherent	90	123.5	

1. R_c = Range to which detection coverage is continuous.

2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval for which detection is possible.

CONFIDENTIAL

(C) Table IIB-7f. Detection Range in Kilometers as a Function of Figure of Merit (FOM) in dB for Hays-Murphy Mediterranean Experimental Data and FACT PL9D Model Predictions
Case VI:
(Source Depth = 80 ft., Receiver Depth = 350 ft., Frequency = 100 Hz).
Bottom Loss: FNOC Type 3.

Data Set	FOM	R_c[1]	Range > R_c
Hays-Murphy	75	17.0	ZDC[2] 10%, 17-41 km
FACT Coherent	75	1.5	
FACT Semicoherent	75	1.5	
FACT Incoherent	75	1.5	
Hays-Murphy	80	42.0	ZDC 10%, 42-52 km
FACT Coherent	80	2.0	ZDC 50%, 2-42 km
FACT Semicoherent	80	1.5	ZDC 50%, 1.5-42.5 km
FACT Incoherent	80	17.5	100% coverage, 27-41.5 km
Hays-Murphy	85	54.0	ZDC 90%, 52-127 km
FACT Coherent	85	3.0	ZDC 70%, 3-80.5 km
FACT Semicoherent	85	1.5	ZDC 80%, 1.5-81 km
FACT Incoherent	85	48.0	100% coverage, 62-81 km
Hays-Murphy	90	> 200.0	
FACT Coherent	90	15.5	100% coverage, 17-46 and 48-163 km
FACT Semicoherent	90	162.0	
FACT Incoherent	90	123.5	100% coverage, 133.5-161.5 and 181-193 km

1. R_c = Range to which detection coverage is continuous.

2. ZDC - Zonal Detection Coverage in percentage of the indicated range interval for which detection is possible.

CONFIDENTIAL

CONFIDENTIAL

(C) Table IIB-8a. Detection Range in Kilometers as a Function of Figure of Merit (FOM) in dB for Hays-Murphy Mediterranean Experimental Data and FACT PL9D Model Predictions
CASE I:
(Source Depth = 80 ft., Receiver Depth = 450 ft., Frequency = 35 Hz).
Bottom Loss: MGS Type 2.

Data Set	FOM	R_c [1]	Range > R_c
Hays-Murphy	75	25.5	ZDC[2] 60%, 25.5-44 km
FACT Coherent	75	1.5	
FACT Semicoherent	75	1.5	
FACT Incoherent	75	2.0	
Hays-Murphy	80	54.5	ZDC 50%, 54.5-93 km
FACT Coherent	80	1.5	ZDC 40%, 1.5-32 km
FACT Semicoherent	80	1.5	ZDC 50%, 1.5-32 km
FACT Incoherent	80	12.0	
Hays-Murphy	85	130.5	ZDC 50%, 130.5-172.5 km
FACT Coherent	85	2.0	
FACT Semicoherent	85	1.5	100% coverage, 4-52 km
FACT Incoherent	85	1.5	ZDC 85%, 1.5-48 km
Hays-Murphy	90	> 200.0	
FACT Coherent	90	160.5	
FACT Semicoherent	90	161.0	
FACT Incoherent	90	122.5	

1. R_c = Range to which detection coverage is continuous.

2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval for which detection is possible.

(C) Table IIB-8b. Detection Range in Kilometers as a Function of Figure of Merit (FOM) in dB of Hays-Murphy Mediterranean Experimental Data and FACT PL9D Model Predictions
Case II:
(Source Depth = 80 ft., Receiver Depth = 450 ft., Frequency = 67.5 Hz).
Bottom Loss: MGS Type 2.

Data Set	FOM	R_c[1]	Range > R_c
Hays-Murphy	75	42.5	
FACT Coherent	75	1.5	
FACT Semicoherent	75	1.5	
FACT Incoherent	75	1.5	
Hays-Murphy	80	54.0	ZDC[2] 50%, 54-113 km
FACT Coherent	80	2.0	ZDC 35%, 2-46.5 km
FACT Semicoherent	80	1.5	ZDC 30%, 1.5-47.5 km
FACT Incoherent	80	13.0	100% coverage, 34.5-41.5 km
Hays-Murphy	85	> 200.0	Except for a few dropouts of ≤ 1 km.
FACT Coherent	85	2.5	ZDC 80%, 2.5-79 km
FACT Semicoherent	85	1.5	ZDC 80%, 1.5-80.5 km
FACT Incoherent	85	47.5	100% coverage, 66.5-80 km
Hays-Murphy	90	> 200.0	
FACT Coherent	90	8.5	100% coverage to 186.5 km except for 54-56 & 141.5-161.5 km
FACT Semicoherent	90	162.0	100% coverage, 186-193.5 km
FACT Incoherent	90	123.0	100% coverage, 142-160 km

1. R_c = Range to which detection coverage is continuous.

2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval for which detection is possible.

(C) Table IIB-8c. Detection Range in Kilometers as a Function of Figure of Merit (FOM) in dB for Hays-Murphy Mediterranean Experimental Data and FACT PL9D Model Predictions
Case III:
(Source Depth = 80 ft., Receiver Depth = 450 ft., Frequency = 100 Hz).
Bottom Loss: MGS Type 2.

Data Set	FOM	R_c [1]	Range > R_c
Hays-Murphy	75	17.5	ZDC[2] 60%, 17.5-42 km
FACT Coherent	75	1.5	
FACT Semicoherent	75	1.5	
FACT Incoherent	75	1.5	
Hays-Murphy	80	43.5	ZDC 20%, 43.5-84 km
FACT Coherent	80	1.5	ZDC 50%, 1.5-44.5 km
FACT Semicoherent	80	1.5	ZDC 40%, 1.5-44 km
FACT Incoherent	80	14.0	100% coverage, 32-41.5 km
Hays-Murphy	85	127.5	ZDC 70%, 127.5-190 km
FACT Coherent	85	3.0	ZDC 70%, 3-80.5 km
FACT Semicoherent	85	1.5	ZDC 75%, 1.5-81 km
FACT Incoherent	85	47.5	100% coverage, 66.5-80 km
Hays-Murphy	90	> 200.0	
FACT Coherent	90	15.0	100% coverage except 15-18, 48-49, 123-127.5, 161.5-181, 189->200 km
FACT Semicoherent	90	1.5	100% coverage (except three 1-km dropouts) to 123.5 km; 100% coverage 162-181 & 191-200km
FACT Incoherent	90	123.5	100% coverage, 139-161.5 and 181-193.5 km

1. R_c = Range to which detection coverage is continuous.
2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval for which detection is possible.

CONFIDENTIAL

(C) Table IIB-8d. Detection Range in Kilometers as a Function of Figure of Merit (FOM) in dB for Hays-Murphy Mediterranean Experimental Data and FACT PL9D Model Predictions
Case IV:
(Source Depth = 80 ft., Receiver Depth = 450 ft., Frequency = 100 Hz).
Bottom Loss: MGS Type 2

Data Set	FOM	R_c [1]	Range > R_c
Hays-Murphy	75	21.5	ZDC[2] 90%, 21.5-37.5 km
FACT Coherent	75	1.5	
FACT Semicoherent	75	1.5	
FACT Incoherent	75	1.5	
Hays-Murphy	80	42.5	ZDC 50%, 42.5-95 km
FACT Coherent	80	2.5	100% coverage, 4-8 and 32-39.5 km
FACT Semicoherent	80	2.0	ZDC 40%, 2-40 km
FACT Incoherent	80	10.5	100% coverage, 32.5-40.5 km
Hays-Murphy	85	194.0	
FACT Coherent	85	9.0	ZDC 50%, 9-78.5 km
FACT Semicoherent	85	2.0	ZDC 50%, 2-78 km
FACT Incoherent	85	47.5	100% coverage, 66-79 km
Hays-Murphy	90	>200.0	
FACT Coherent	90	44.5	100% coverage 47-53.5, 57-81 and 95-121 km
FACT Semicoherent	90	82.0	100% coverage, 97-121 km
FACT Incoherent	90	48.0	100% coverage, 52-81.5, 91-121 & 133-146 km

1. R_c = Range to which detection coverage is continuous.
2. ZDC = Zonal Detection Coverage in percentage of indicated range interval for which detection is possible.

CONFIDENTIAL

(C) Table IIB-8e. Detection Range in Kilometers as a Function of Figure of Merit (FOM) in dB for Hays-Murphy Mediterranean Experimental Data and FACT PL9D Model Predictions
Case V:
(Source Depth = 80 ft., Receiver Depth = 350 ft., Frequency = 35 Hz).
Bottom Loss: MGS Type 2

Data Set	FOM	R_c[1]	Range $>R_c$
Hays-Murphy	75	25.5	ZDC[2] 50%, 25.5-47 km
FACT Coherent	75	2.0	
FACT Semicoherent	75	2.0	
FACT Incoherent	75	2.0	
Hays-Murphy	80	55.0	ZDC 40%, 55-93 km
FACT Coherent	80	2.0	ZDC 50%, 2-24 km
FACT Semicoherent	80	2.0	ZDC 50%, 2-24 km
FACT Incoherent	80	11.0	
Hays-Murphy	85	118.0	ZDC 50%, 118-188 km
FACT Coherent	85	2.0	ZDC 95%, 2-49 km
FACT Semicoherent	85	2.0	ZDC 90%, 2-50 km
FACT Incoherent	85	47.5	
Hays-Murphy	90	>200.0	
FACT Coherent	90	2.5	100% coverage, 4-122 km
FACT Semicoherent	90	122.5	
FACT Incoherent	90	122.5	

1. R_c = Range to which detection coverage is continuous.

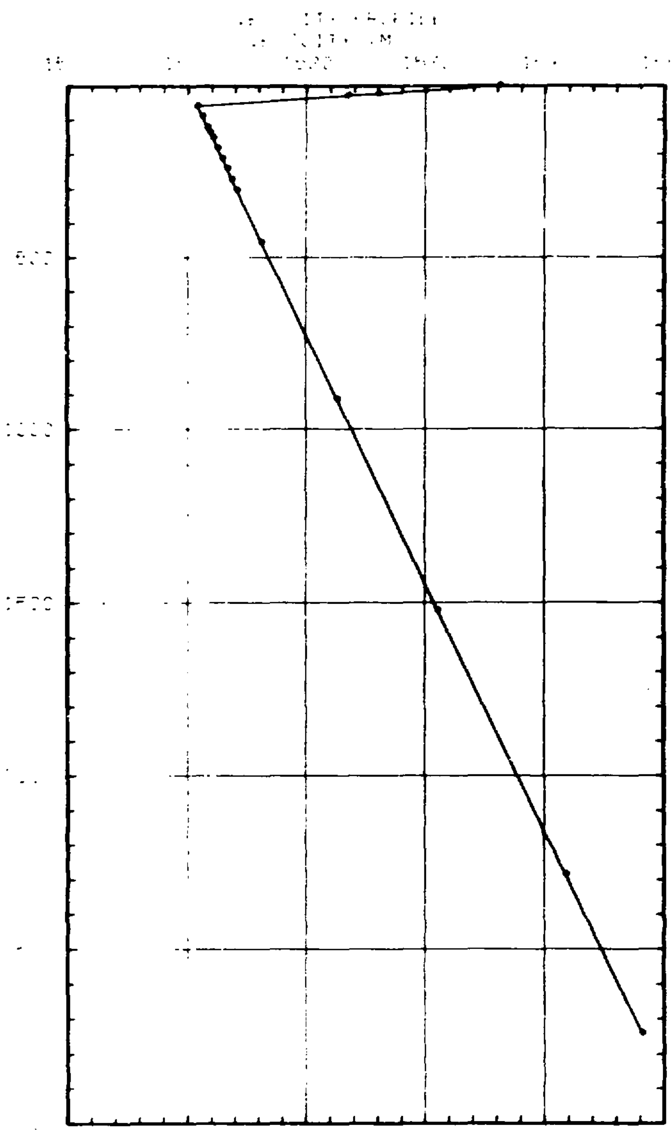
2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval for which detection is possible

(C) Table IIB-8f. Detection Range in Kilometers as a Function of Figure of Merit (FOM) in dB for Hays-Murphy Mediterranean Experimental Data and FACT PL9D Model Predictions
Case VI:
(Source Depth = 80 ft., Receiver Depth = 350 ft., Frequency = 100 Hz).
Bottom Loss: MGS Type 2

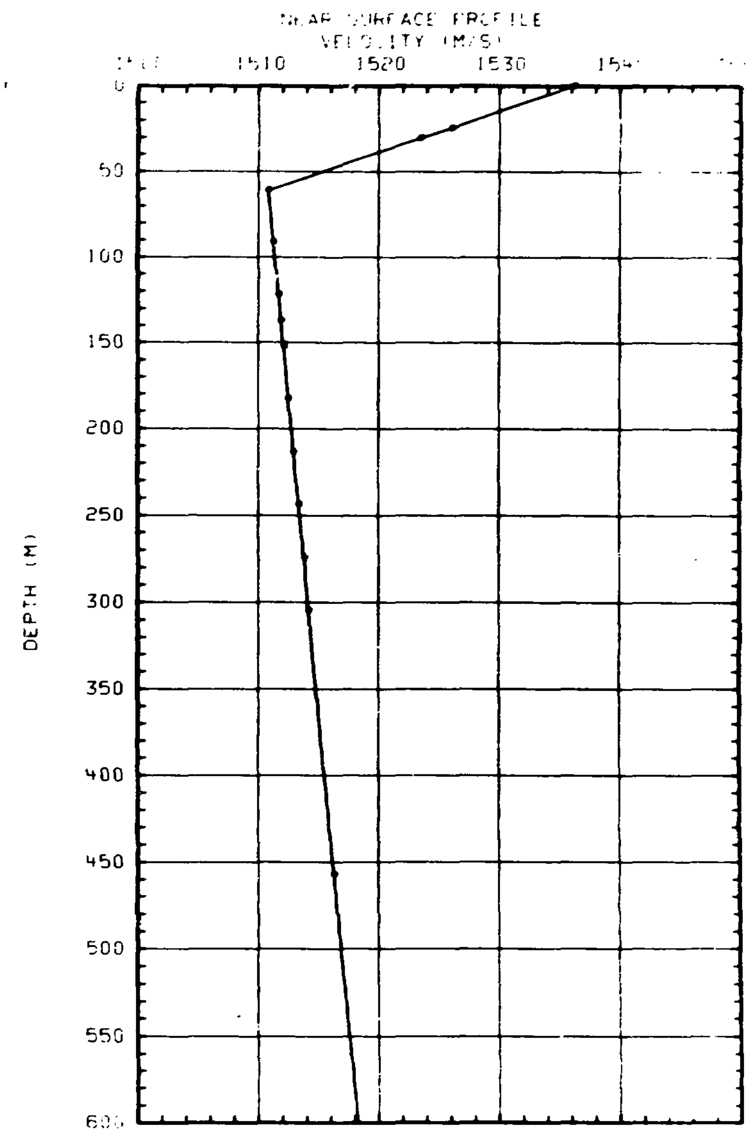
Data Set	FOM	R_c[1]	Range $>R_c$
Hays-Murphy	75	17.0	ZDC[2] 10%, 17-41 km
FACT Coherent	75	1.5	
FACT Semicoherent	75	1.5	
FACT Incoherent	75	1.5	
Hays-Murphy	80	42.0	ZDC 10%, 42-52 km
FACT Coherent	80	2.0	ZDC 50%, 2-42 km
FACT Semicoherent	80	1.5	ZDC 75%, 2-12 km; 100% coverage, 26.5-41.5 km
FACT Incoherent	80	11.5	100% coverage, 34-41 km
Hays-Murphy	85	54.0	ZDC 90%, 52-127 km
FACT Coherent	85	6.5	ZDC 70%, 6.5-80.5 km
FACT Semicoherent	85	1.5	ZDC 70%, 1.5-80 km
FACT Incoherent	85	47.5	100% coverage, 69-80 km
Hays-Murphy	90	>200.0	
FACT Coherent	90	15.5	100% coverage, 17-46 and 48-163 km
FACT Semicoherent	90	162.5	
FACT Incoherent	90	123.0	100% coverage, 139.5-161 km

1. R_c = Range to which detection coverage is continuous.

2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval for which detection is possible.

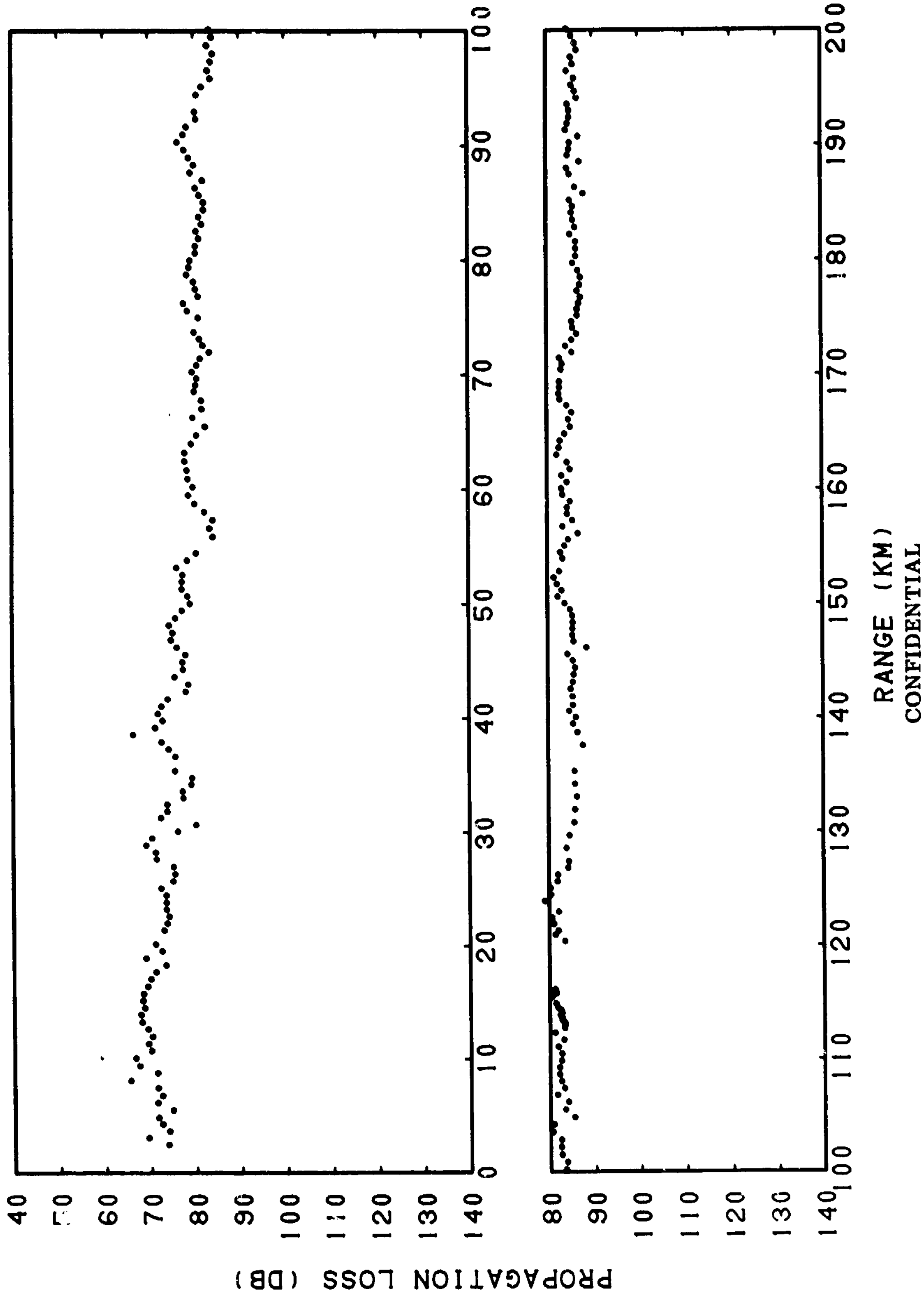


DEPTH	VELOCITY
[illegible]	15[illegible].14
[illegible]	15[illegible].99
30.[illegible]	15[illegible].44
61.0	1510.80
[illegible]1.4	1511.22
12[illegible].9	1511.64
137.2	1511.85
152.4	1512.06
182.9	1512.48
213.4	1512.90
243.8	1513.32
274.3	1513.74
304.8	1514.16
457.2	1516.27
914.4	1522.60
1524.0	1531.08
2286.0	1541.75
2743.0	1548.18

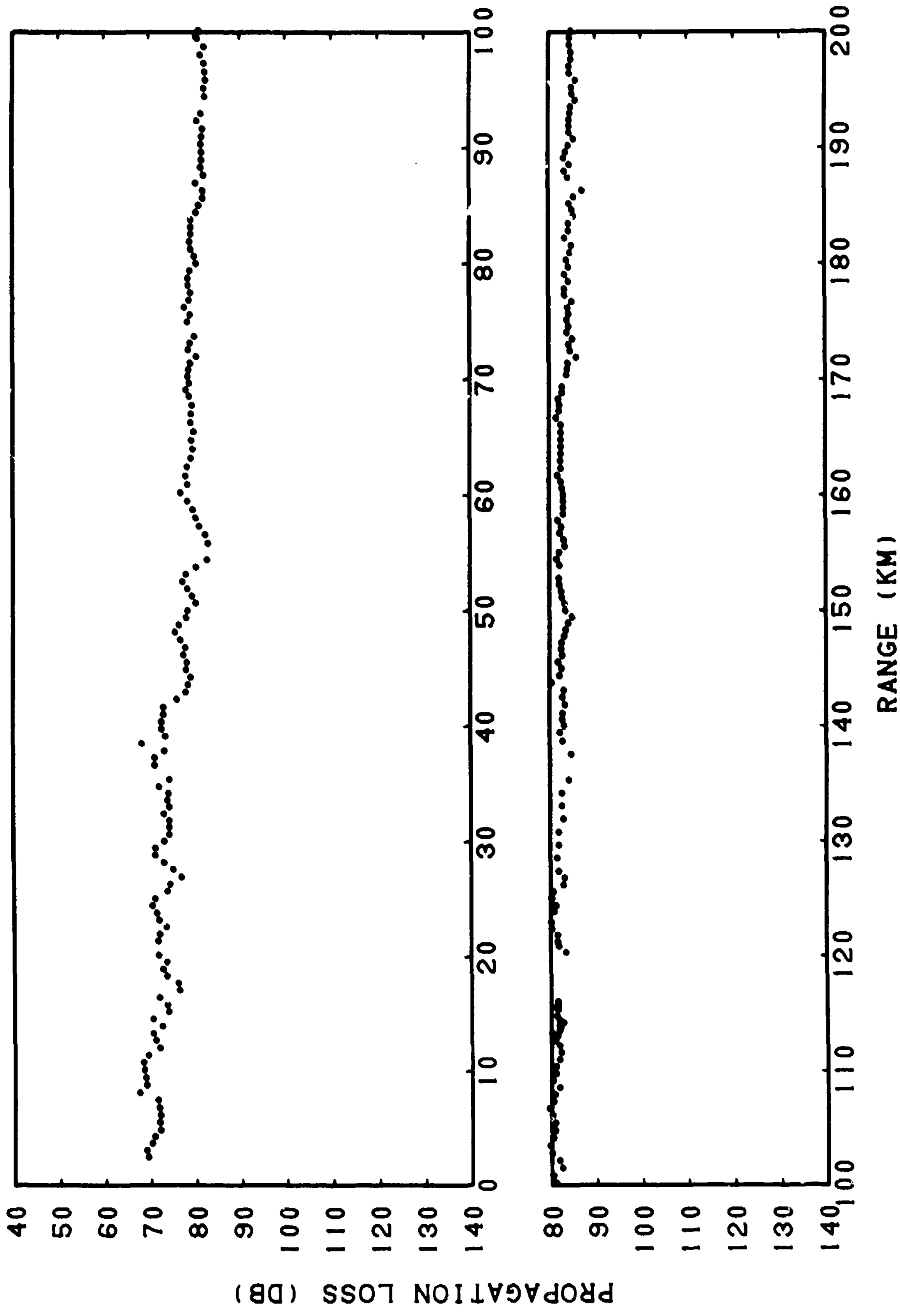


CONFIDENTIAL

(U) Figure IIB-1. Hays-Murphy Sound Speed Versus Depth Profile

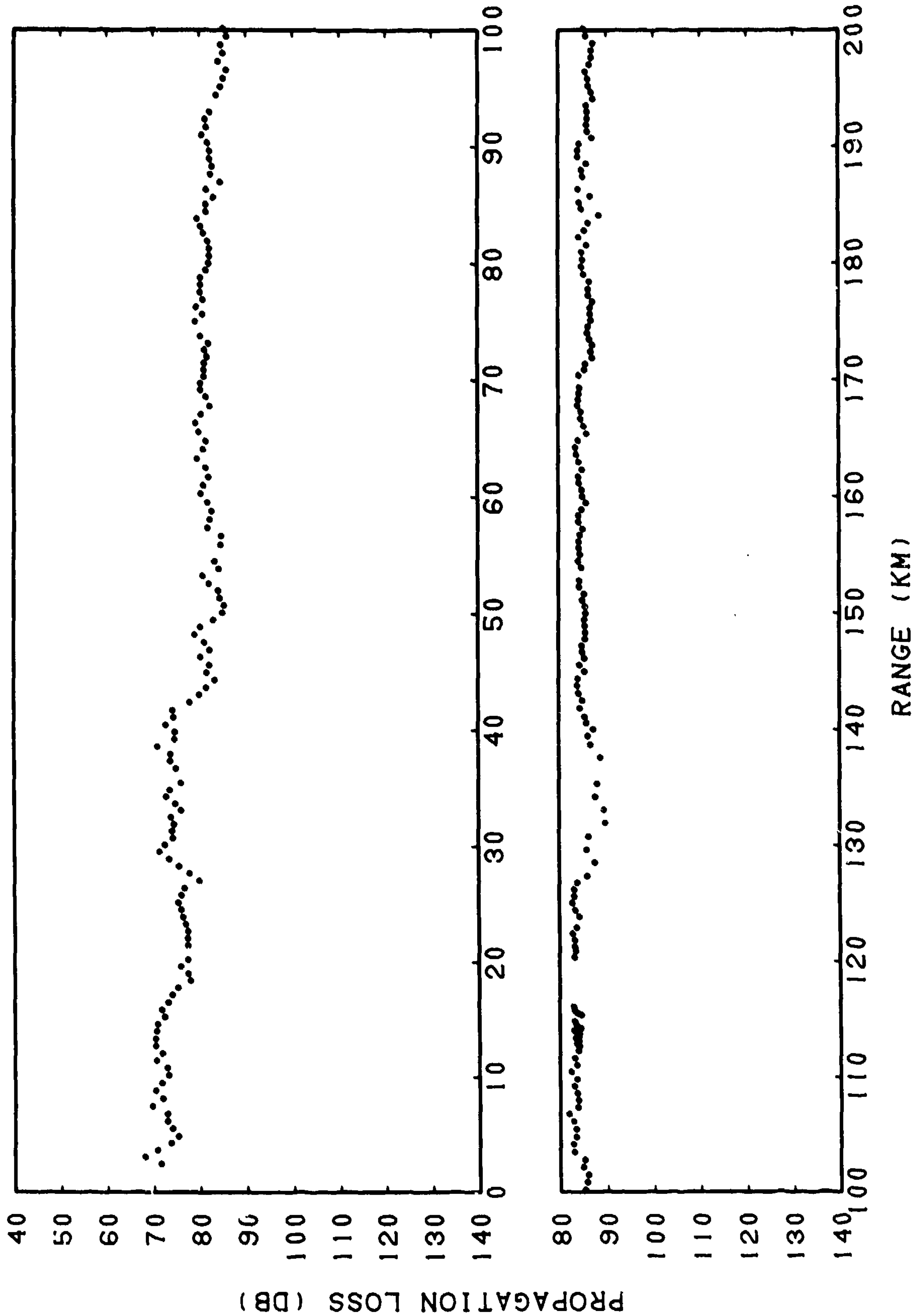


(C) Figure IIB-2. Hays-Murphy Data, Case 1, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 35 Hertz



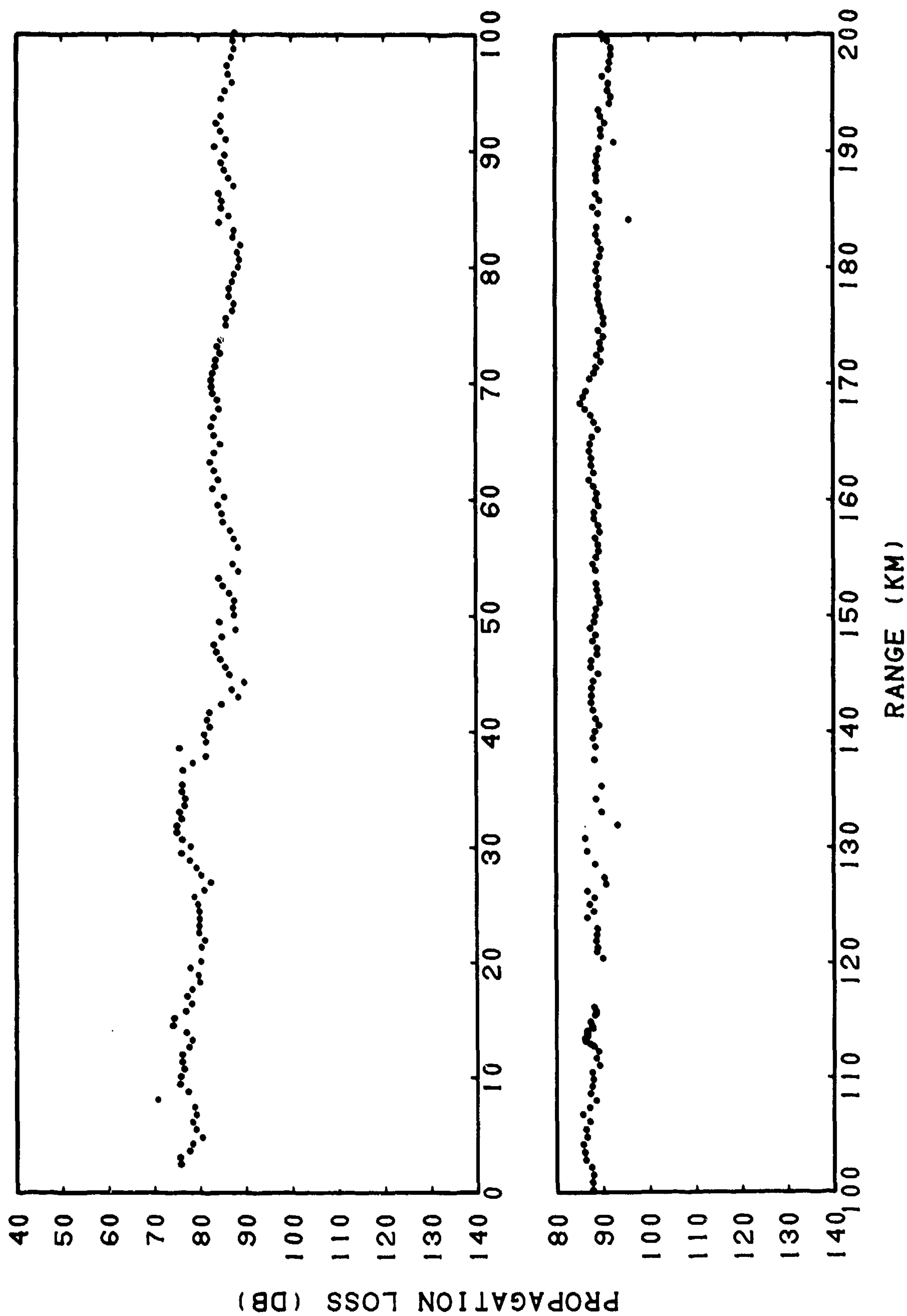
CONFIDENTIAL

(C) Figure IIB-3. Hays-Murphy Data, Case II, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 67.5 Hertz



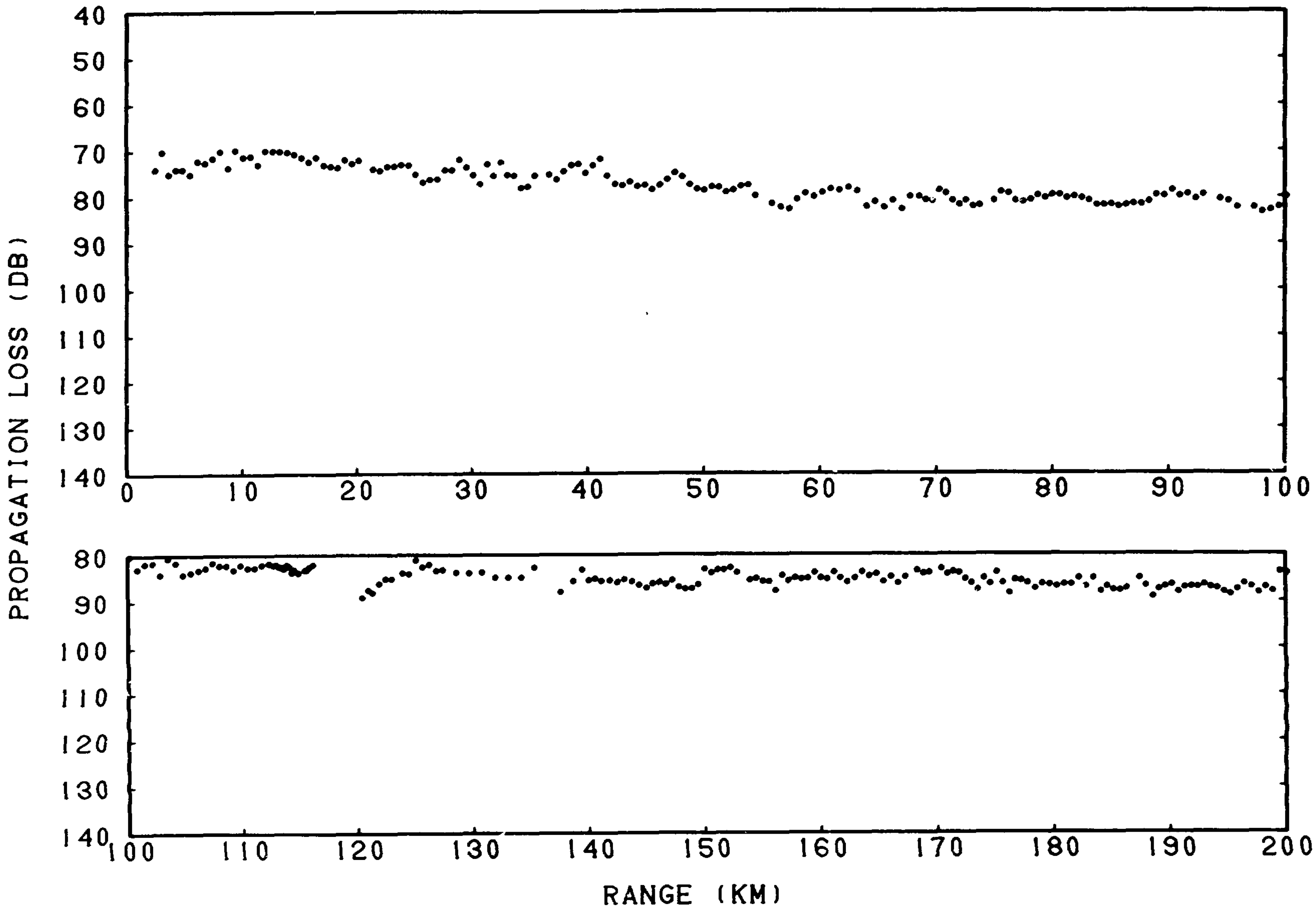
CONFIDENTIAL

(C) Figure IIB-4. Hays-Murphy Data, Case III, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 100 Hertz



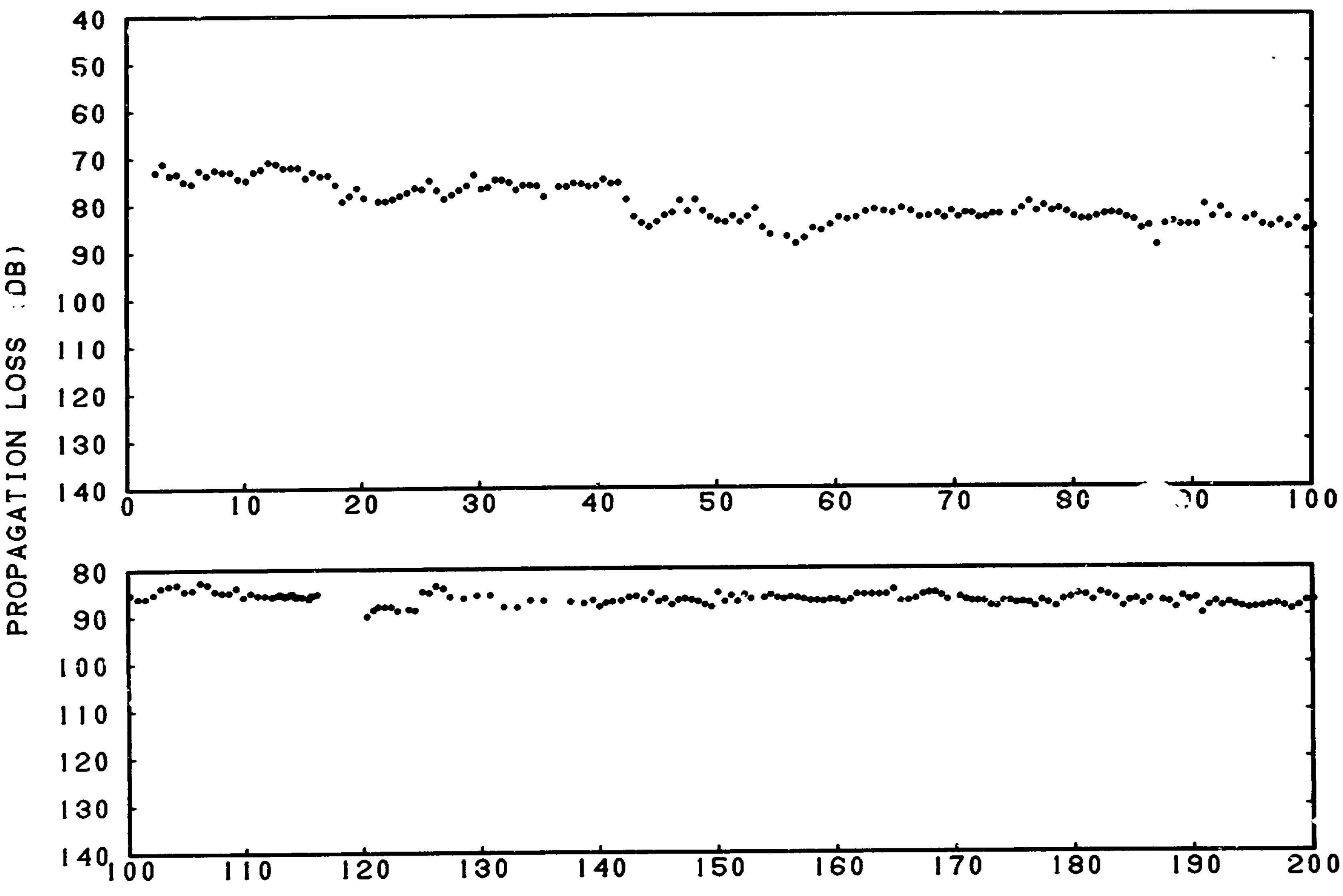
CONFIDENTIAL

(C) Figure IIB-5. Hays-Murphy Data, Case IV, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 200 Hertz



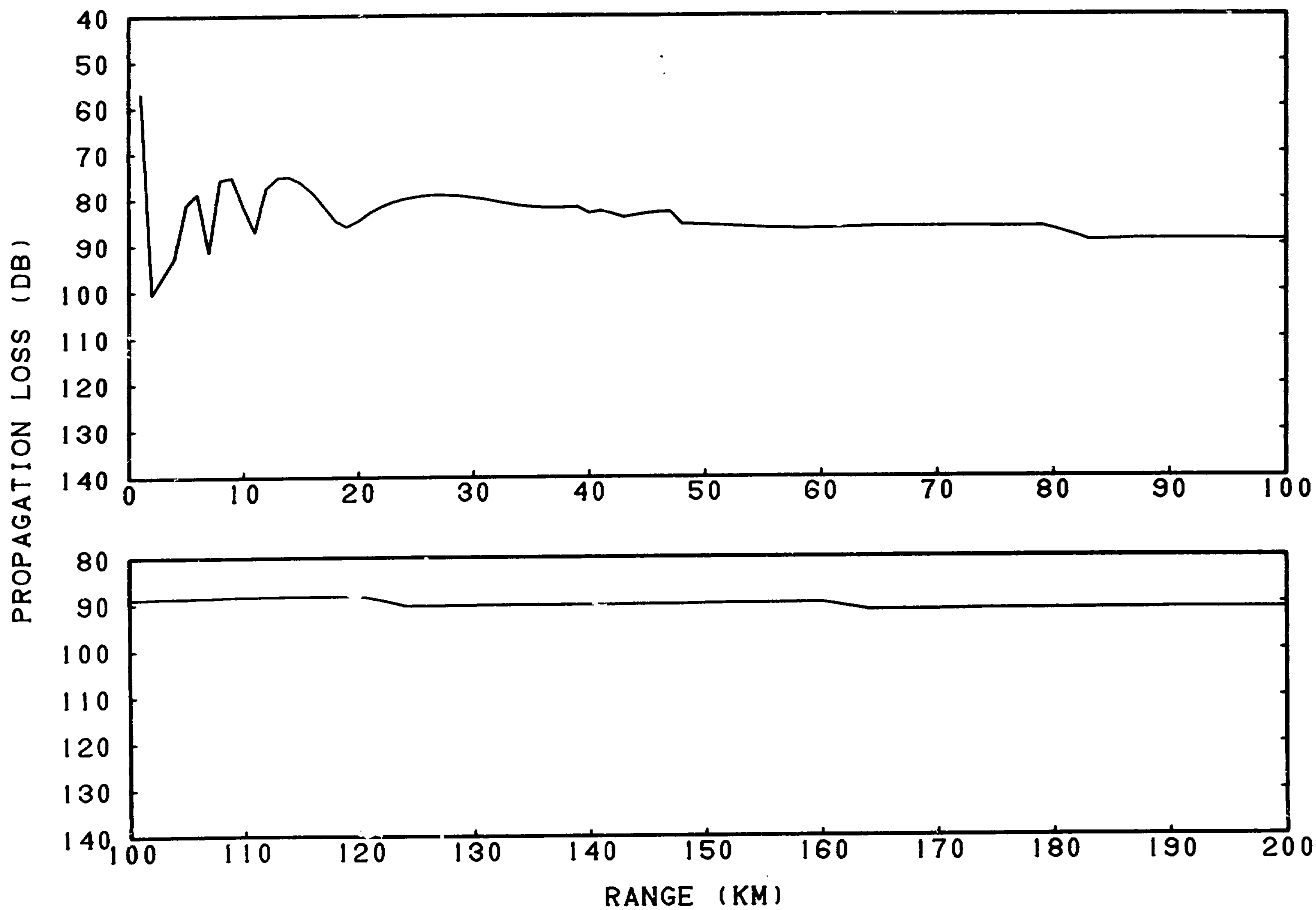
CONFIDENTIAL

(C) Figure IIB-6. Hays-Murphy Data, Case V, Source Depth = 80 Feet, Receiver Depth = 350 Feet, Frequency = 35 Hertz



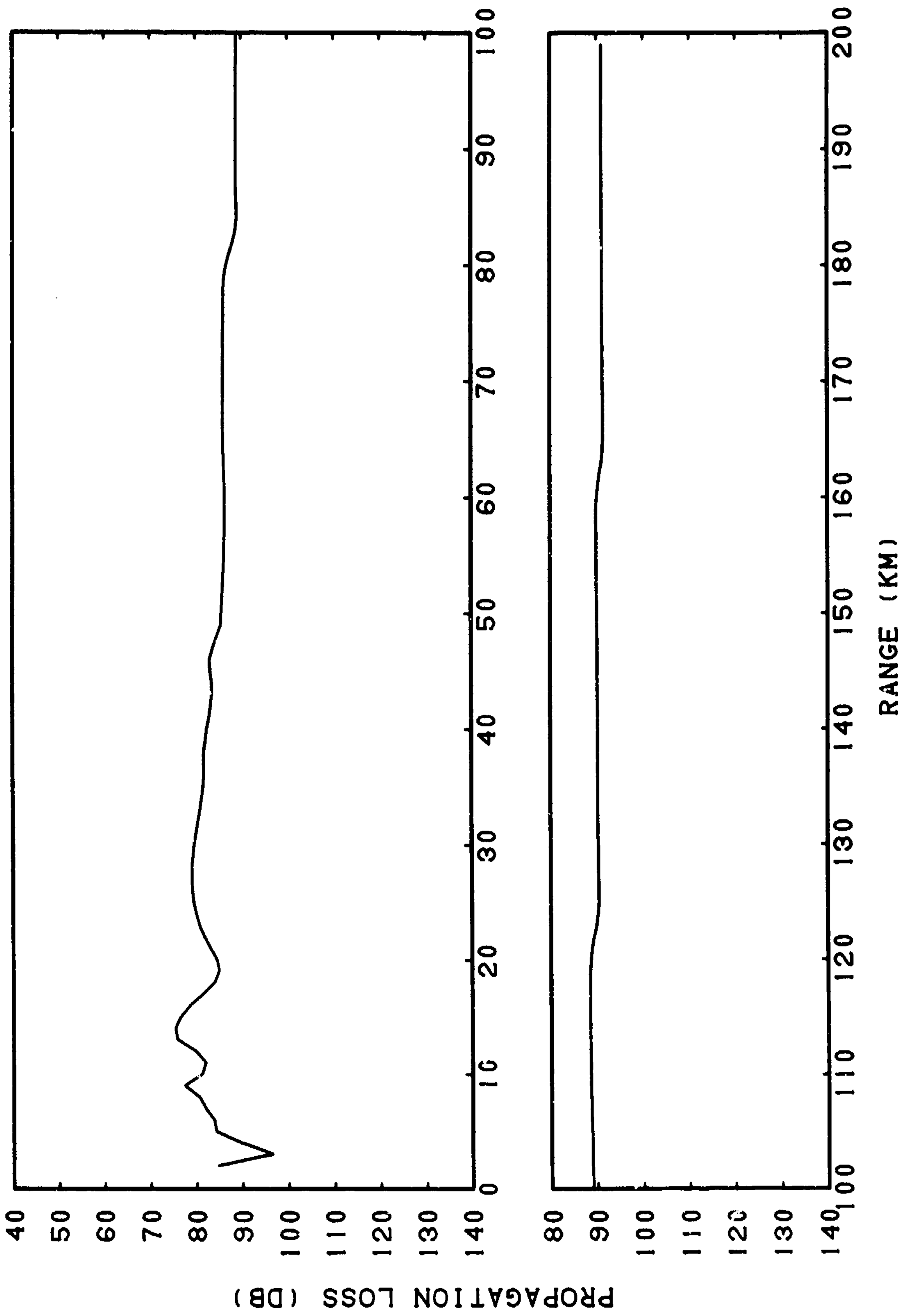
CONFIDENTIAL

(C) Figure IIB-7. Hays-Murphy Data, Case VI, Source Depth = 80 Feet, Receiver Depth = 350 Feet, Frequency = 100 Hertz



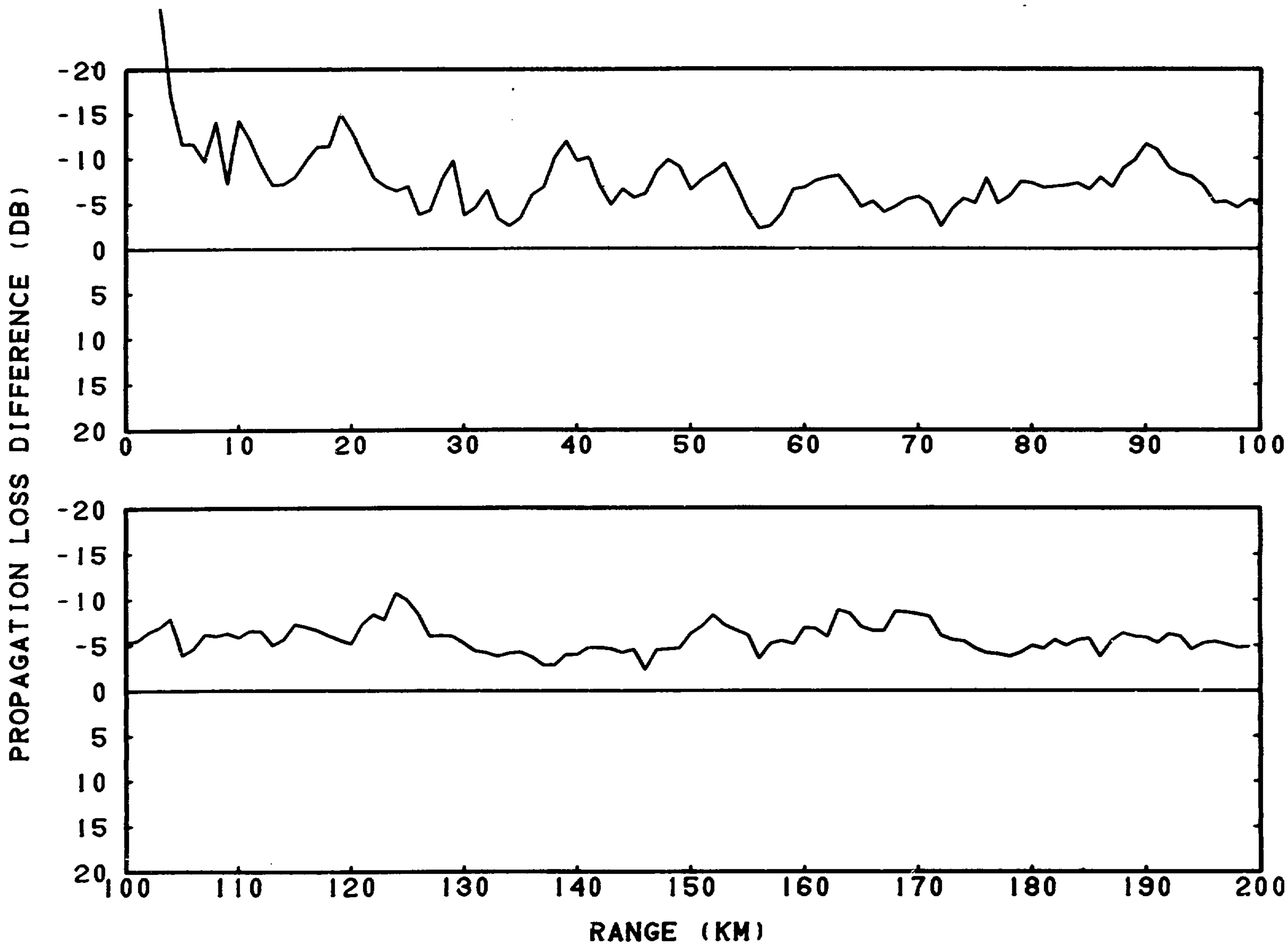
CONFIDENTIAL

(C) Figure IIB-8. FACT (Coherent) Case I, Bottom Loss = FNOC Type 3, Frequency = 35 Hertz



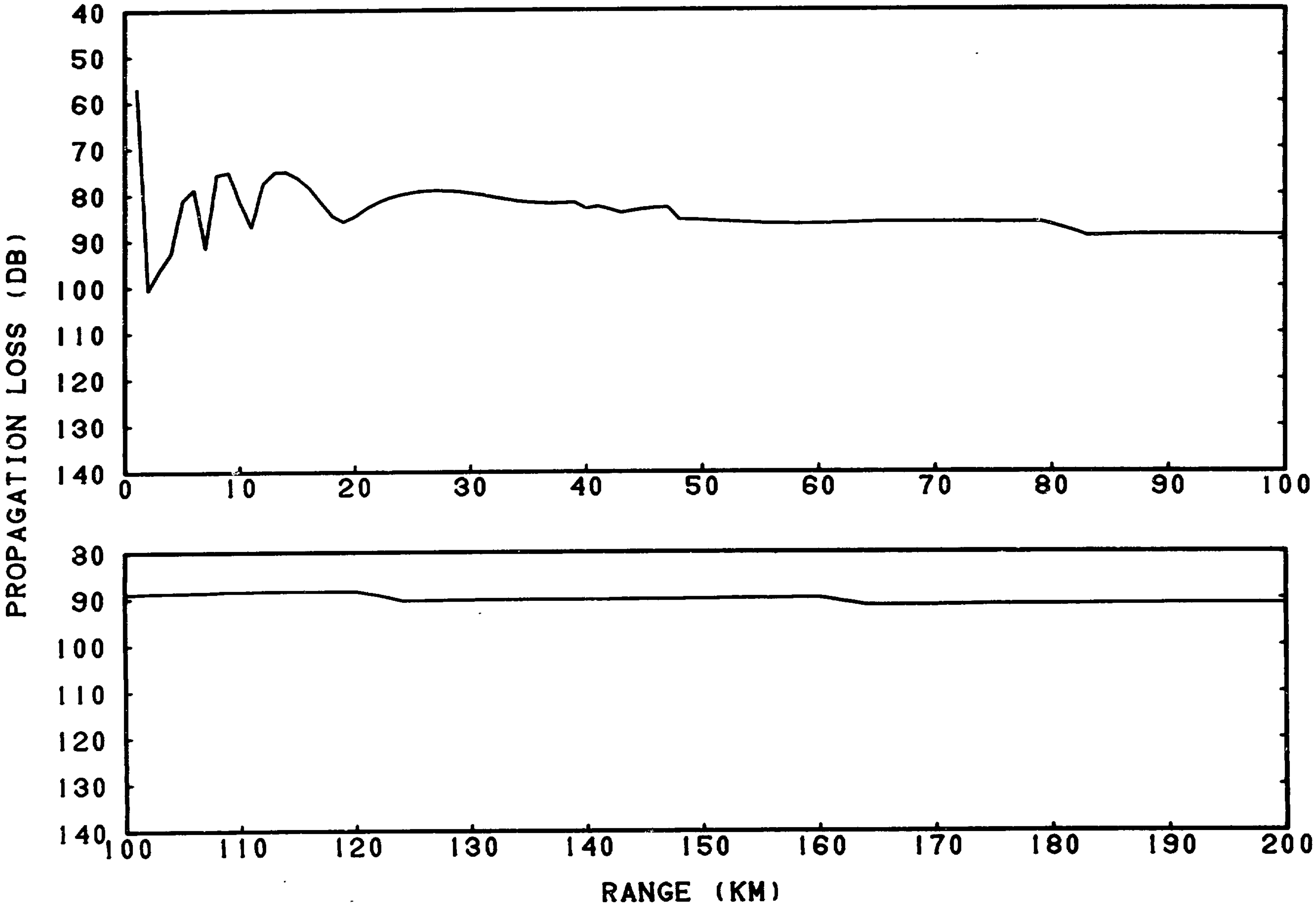
CONFIDENTIAL

(C) Figure IIB-9. FACT (Coherent) Case I, Bottom Loss = FNOC Type 3, Frequency = 35 Hertz, Sliding Averages of 3 Points (2.00 Kilometer)



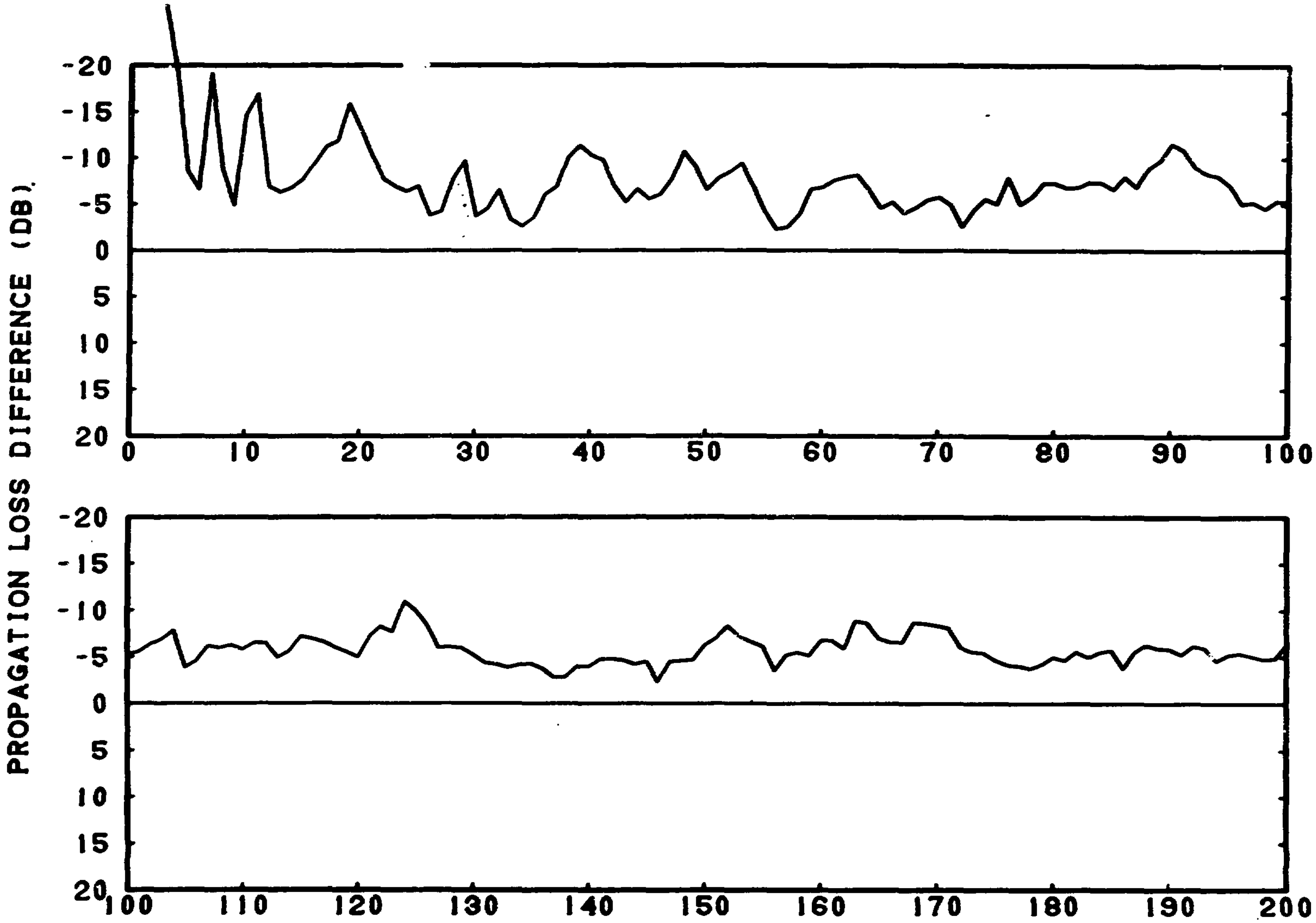
CONFIDENTIAL

(C) Figure IIB-10. Smoothed FACT (Coherent) Case I, Bottom Loss = FNOC Type 3, Frequency = 35 Hertz, Subtracted from Hays-Murphy Data, Case I, Source Depth 80 Feet, Receiver Depth = 450 Feet, Frequency = 35 Hertz



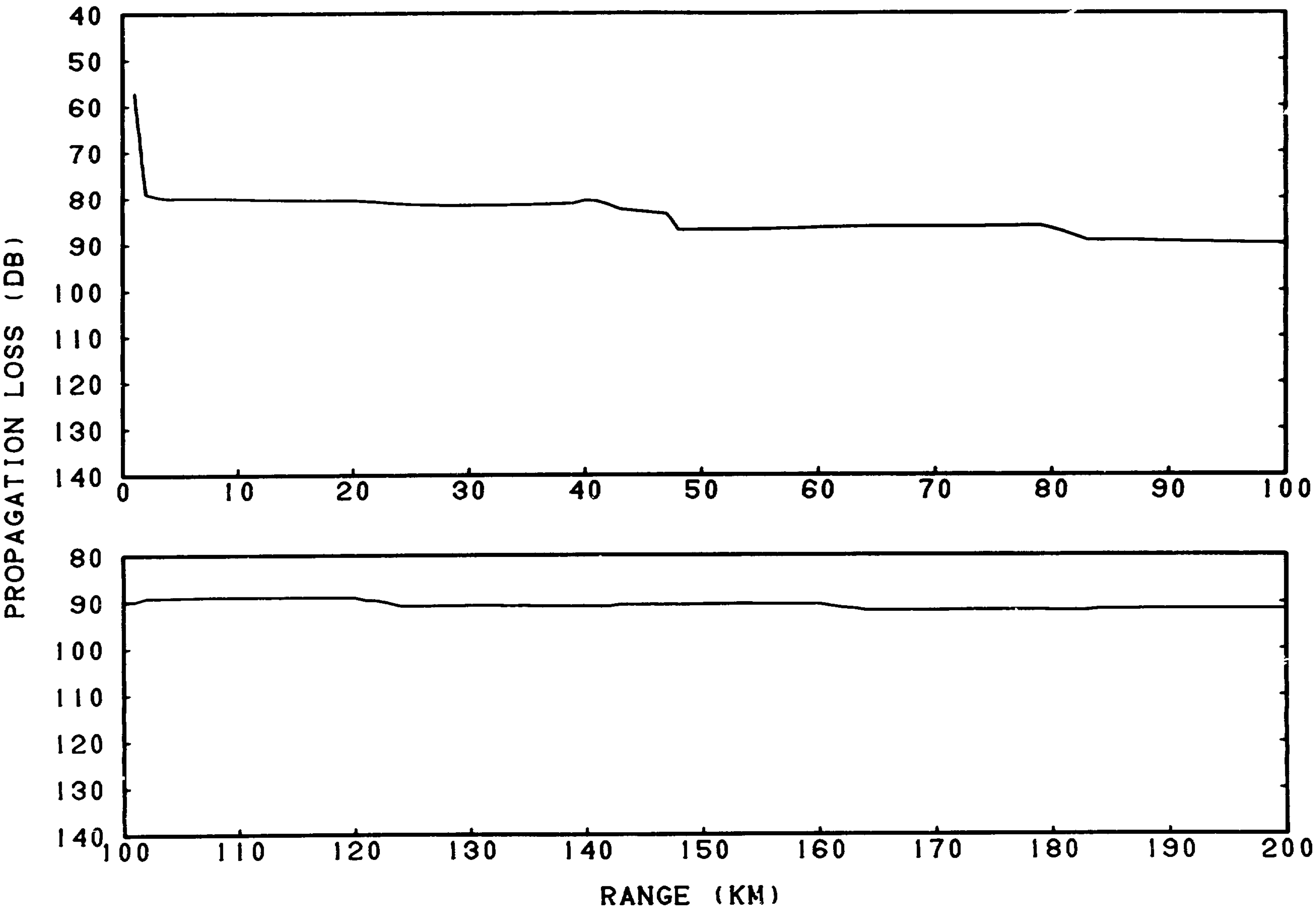
CONFIDENTIAL

(C) Figure IIB-11. FACT (Semi-coherent) Case I, Bottom Loss = FNOC Type 3, Frequency = 35 Hertz



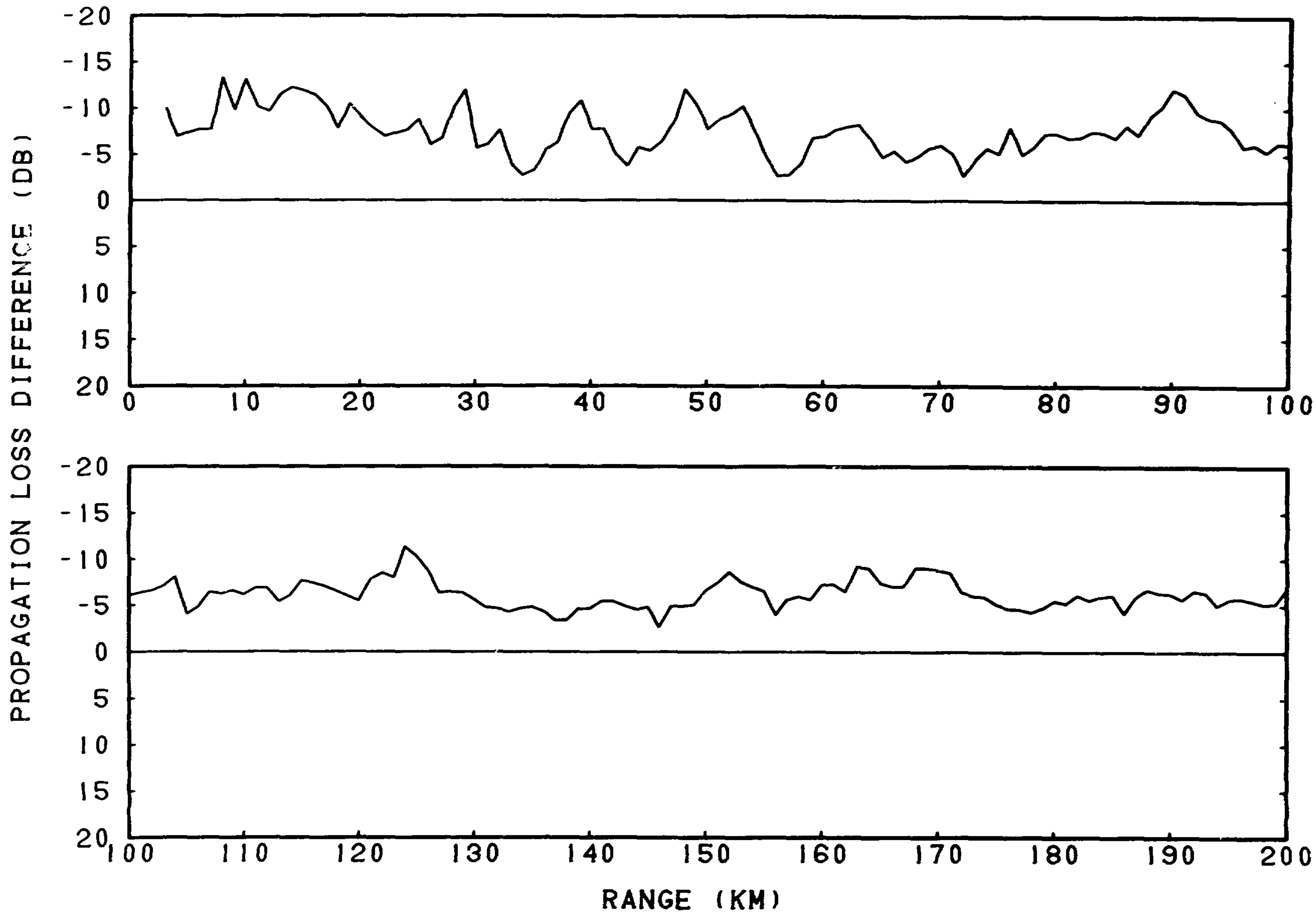
CONFIDENTIAL

(C) Figure IIB-12. FACT (semi-coherent) Case I, Bottom Loss = FNOC Type 3, Frequency = 35 Hertz, Subtracted from Hays-Murphy Data, Case I, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 35 Hertz



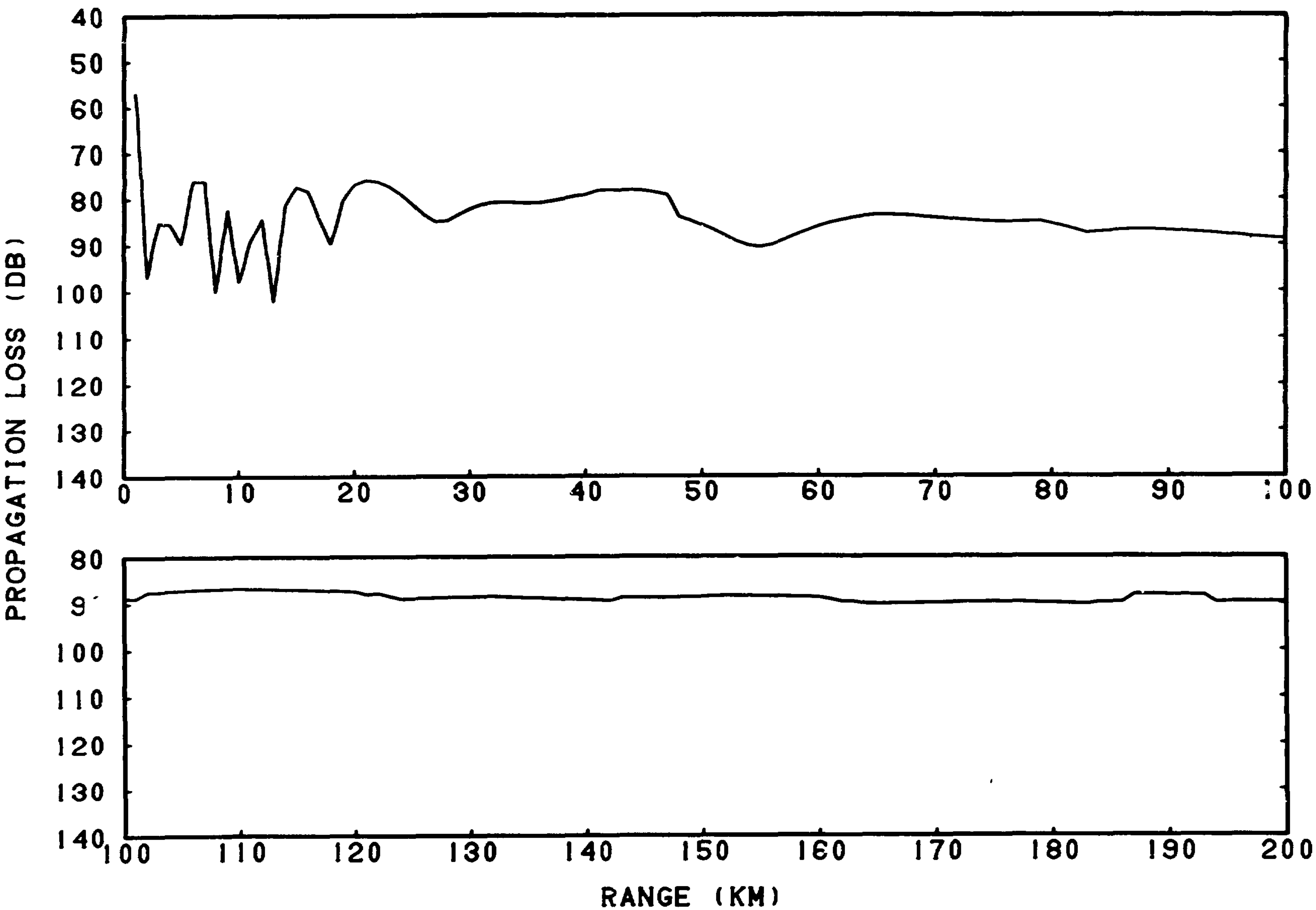
CONFIDENTIAL

(C) Figure IIB-13. FACT (Incoherent) Case I, Bottom Loss = FNOC Type 3, Frequency = 35 Hertz



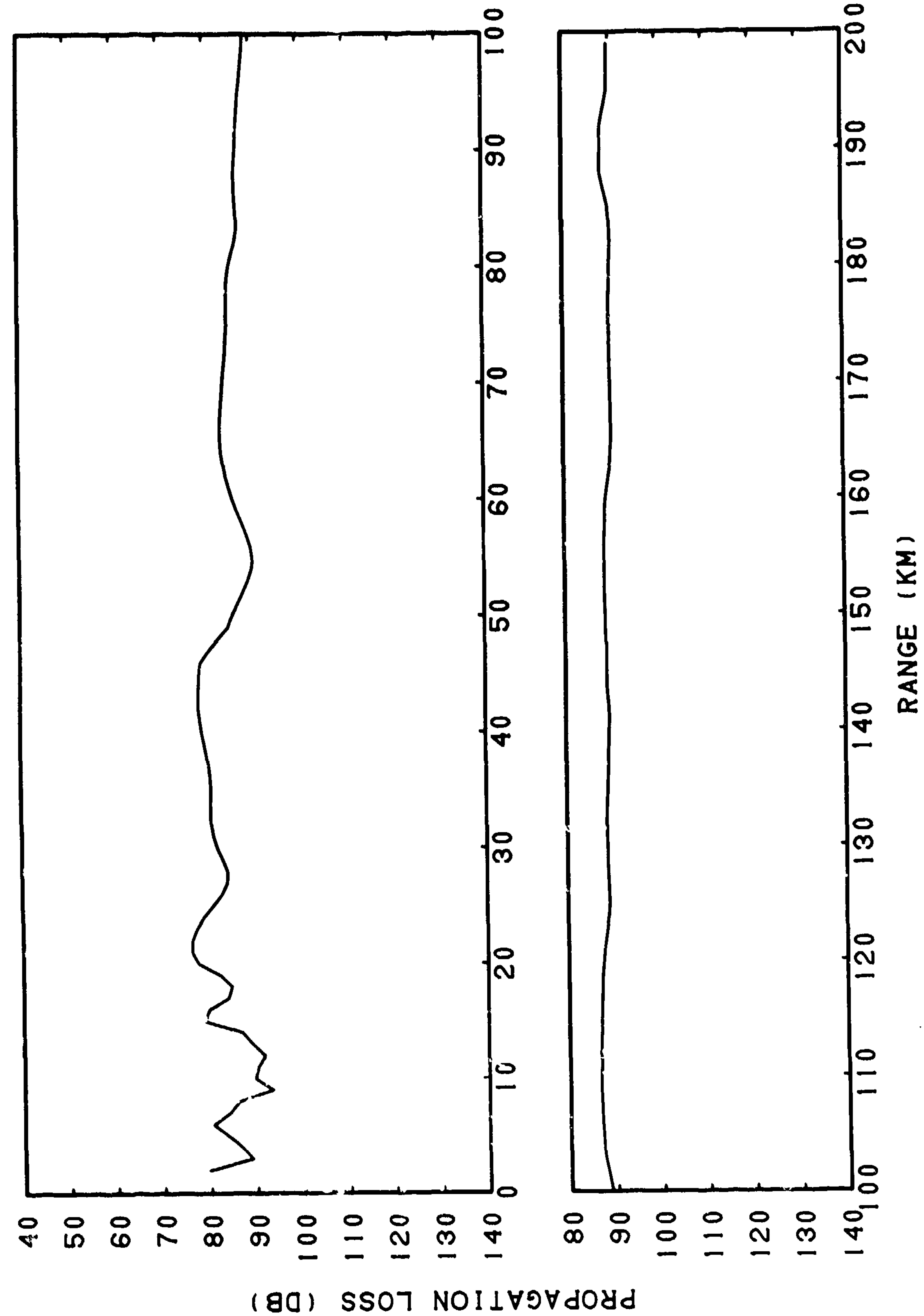
CONFIDENTIAL

(C) Figure IIB-14. FACT (Incoherent) Case I, Bottom Loss = FNOC Type 3, Frequency = 35 Hertz, Subtracted from Hays-Murphy Data, Case I, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 35 Hertz



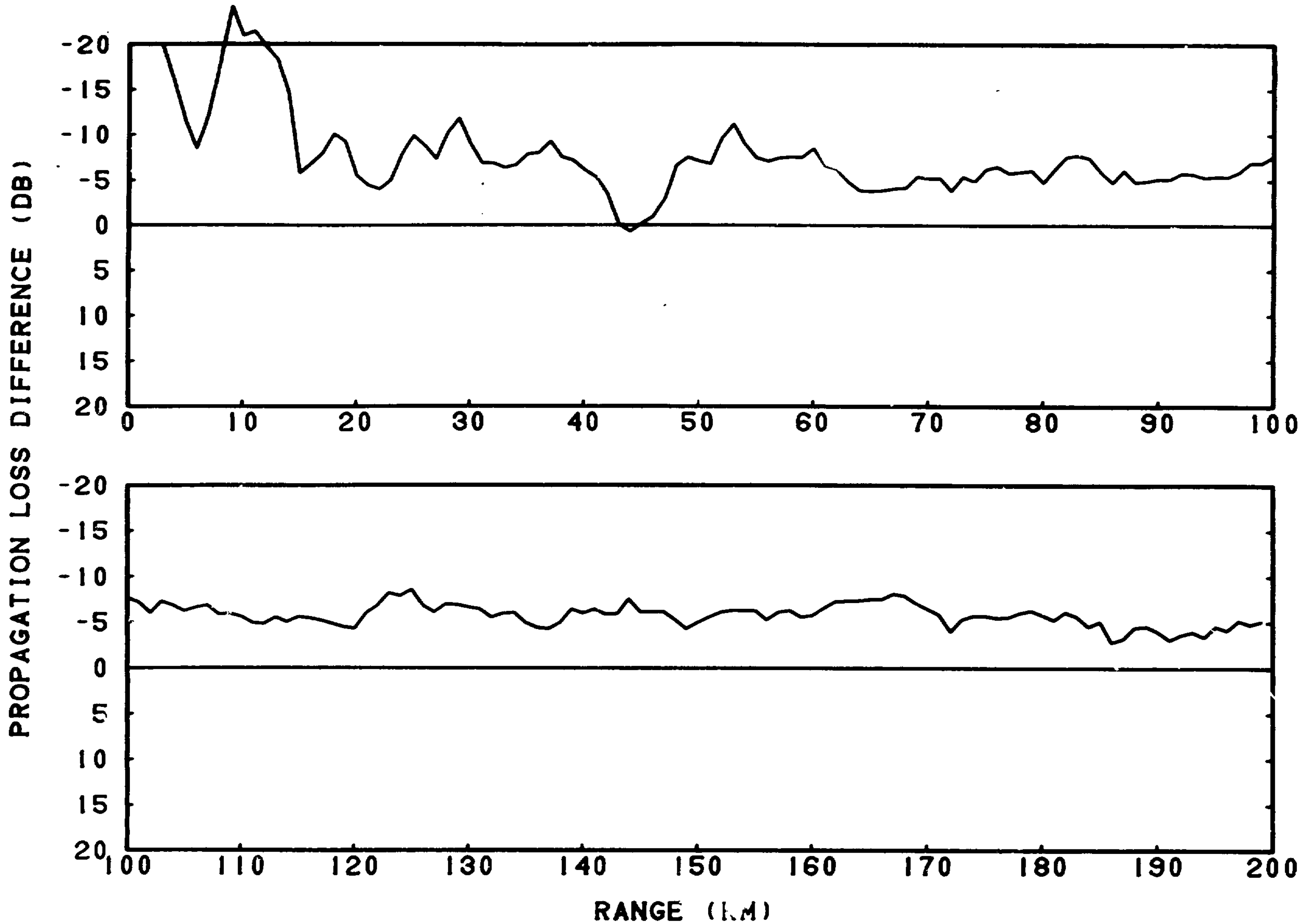
CONFIDENTIAL

(C) Figure IIB-15. FACT (Coherent) Case II, Bottom Loss = FNOC Type 3, Frequency = 67.5 Hertz



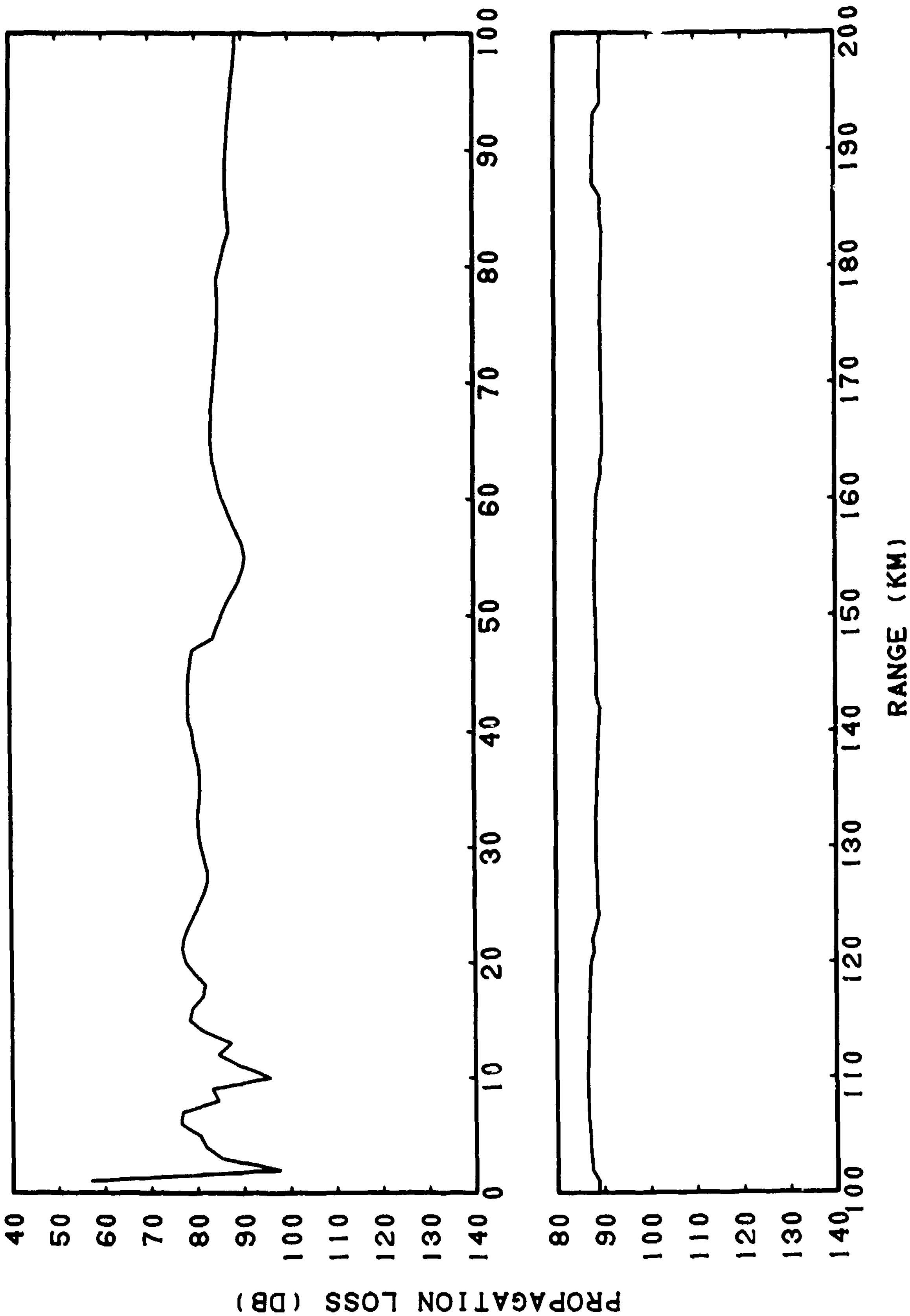
CONFIDENTIAL

(C) Figure IIB-16. FACT (Coherent) Case II, Bottom Loss = FNOC Type 3, Frequency = 67.5 Hertz, Sliding Averages of 3 Points (2.00 Kilometer)



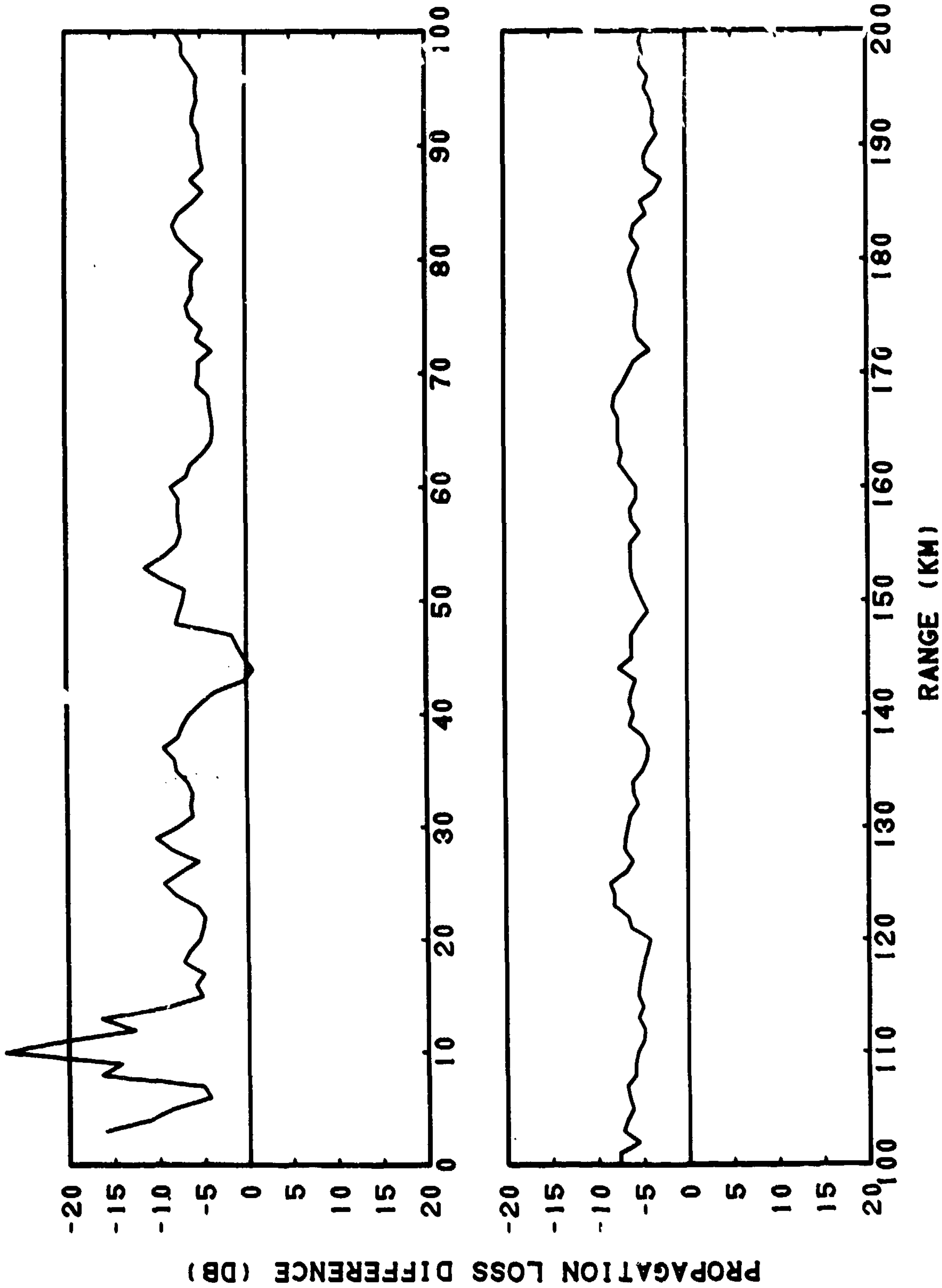
CONFIDENTIAL

(C) Figure IIB-17. Smoothed FACT (Coherent) Case II, Bottom Loss = FNOC Type 3, Frequency = 67.5 Hertz, Subtracted from Hays-Murphy Data, Case II, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 67.5 Hertz



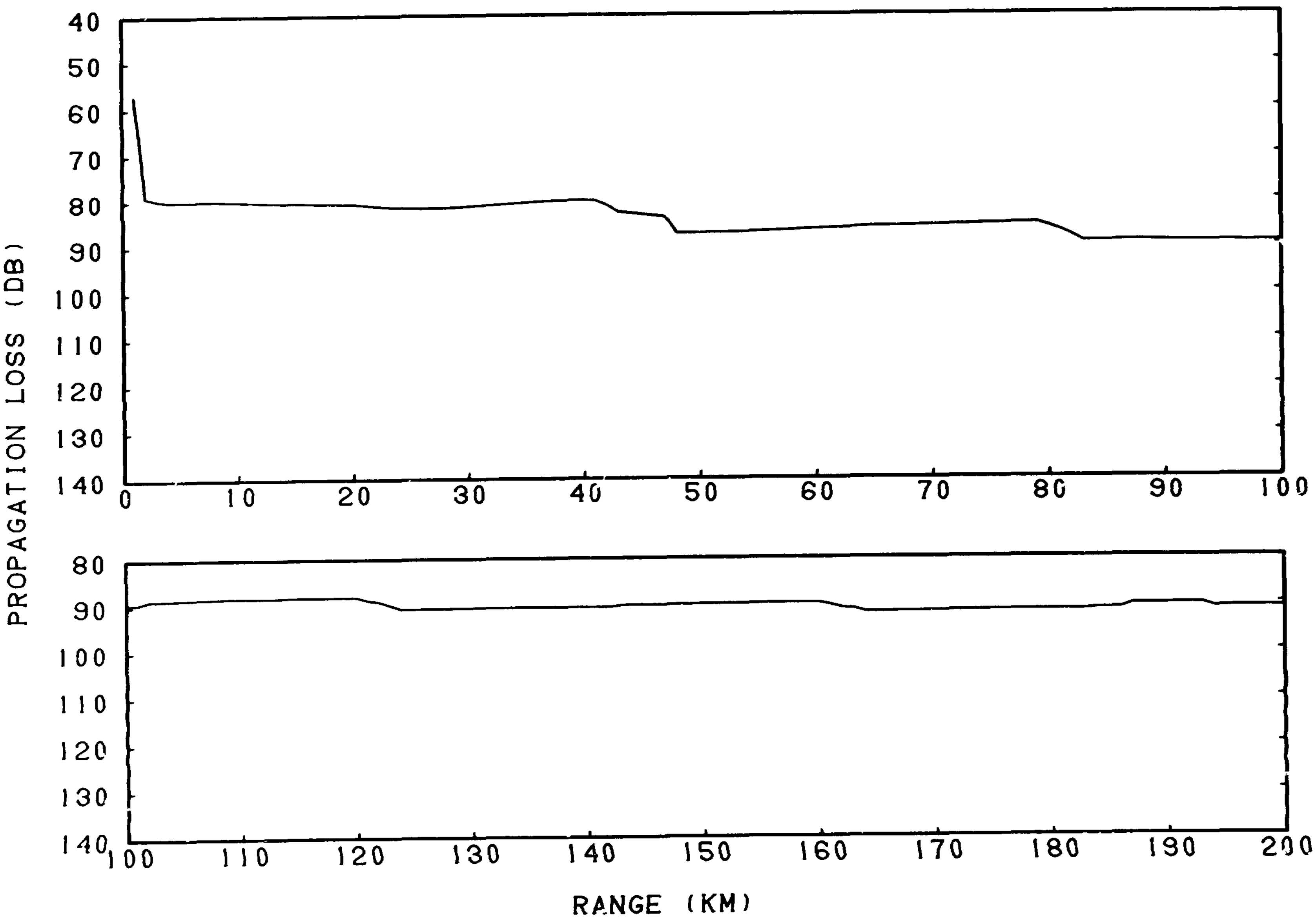
CONFIDENTIAL

(C) Figure IIB-18. FACT (Semi-coherent) Case II, Bottom Loss = FNOC Type 3, Frequency = 67.5 Hertz



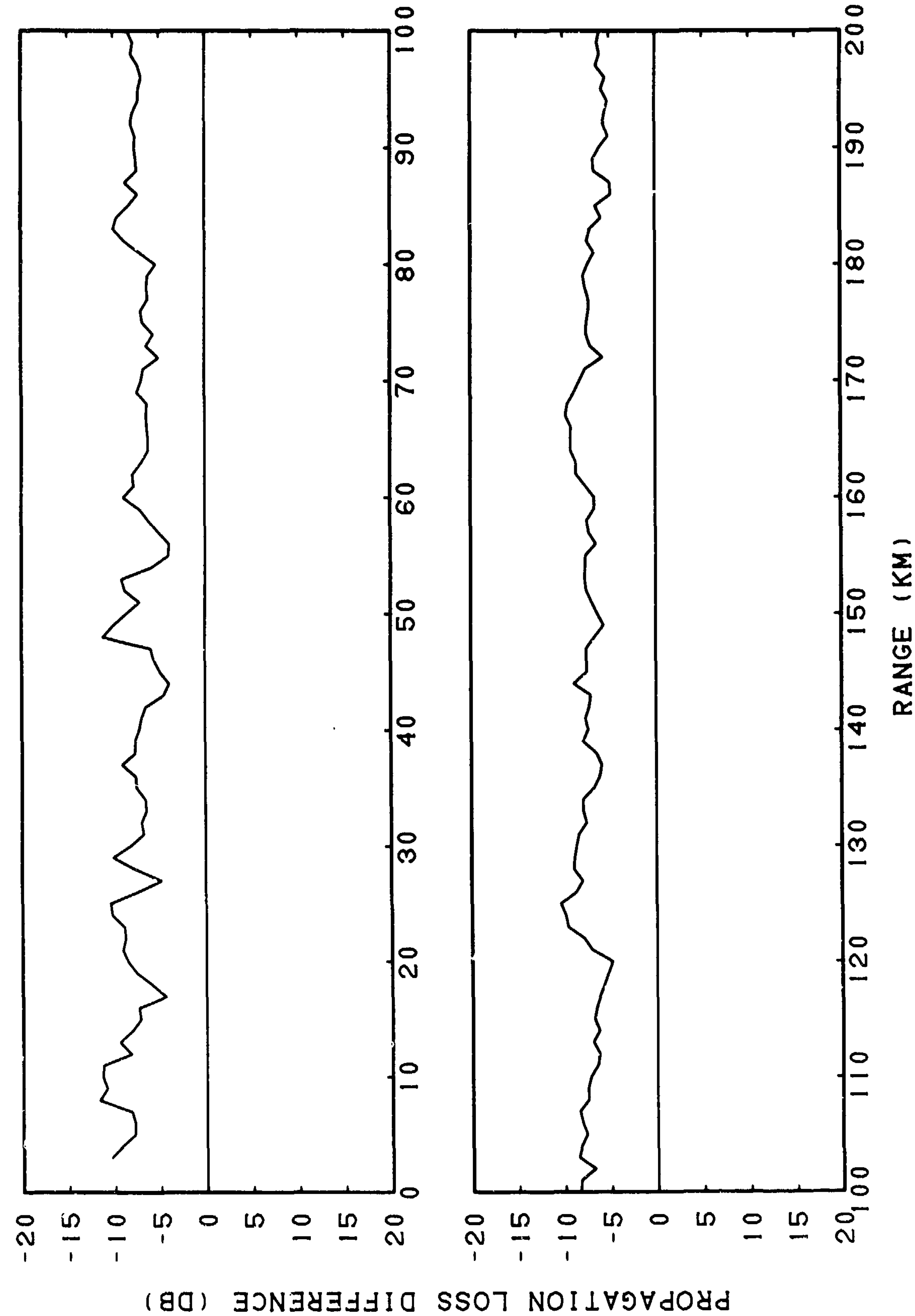
CONFIDENTIAL

(C) Figure IIB-19. FACT (Semi-coherent) Case II, Bottom Loss = FNOC Type 3, Frequency = 67.5 Hertz, Subtracted from Hays-Murphy Data, Case II, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 67.5 Hertz



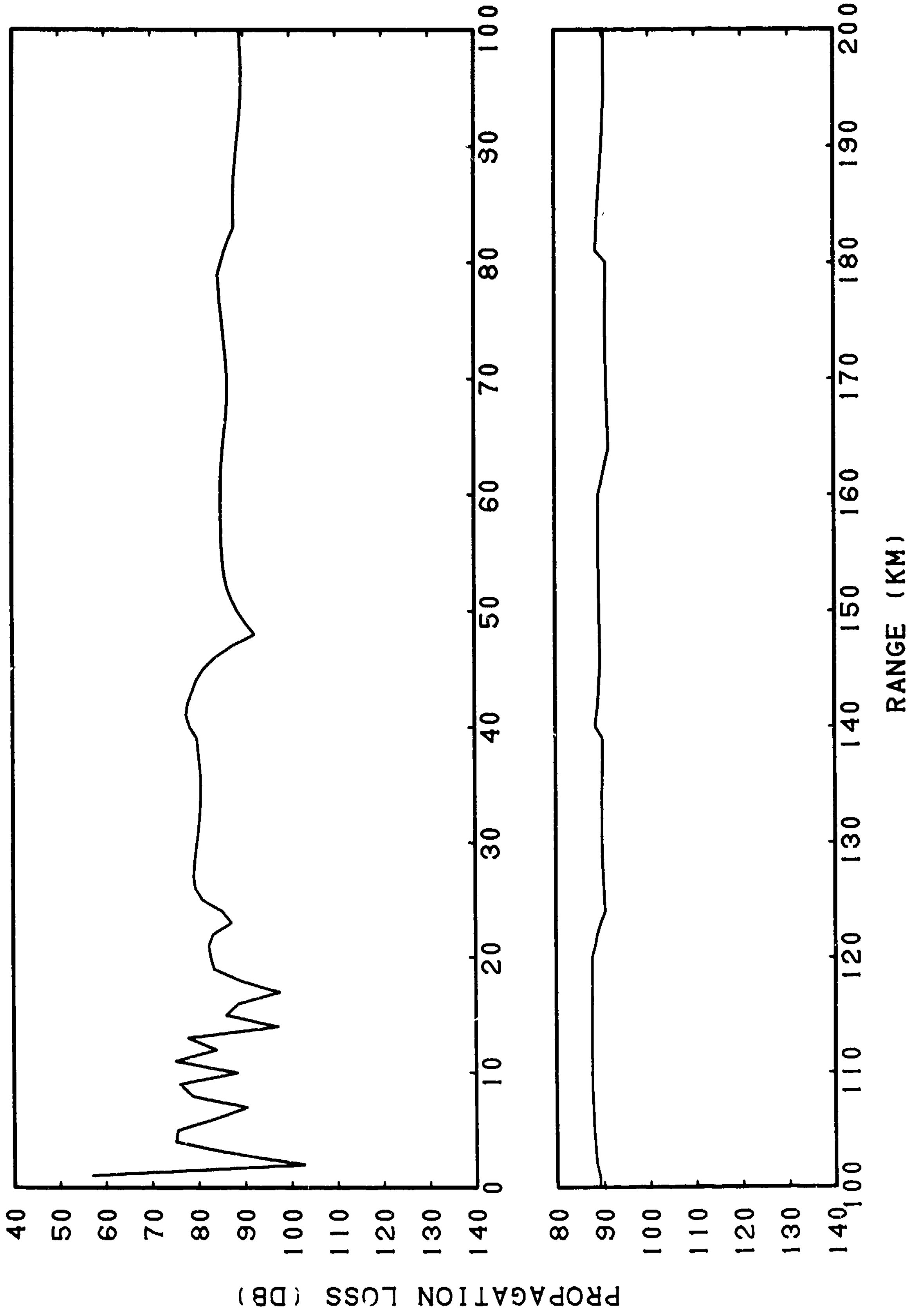
CONFIDENTIAL

(C) Figure IIB-20. FACT (Incoherent) Case II, Bottom Loss = FNOC Type 3, Frequency = 67.5 Hertz



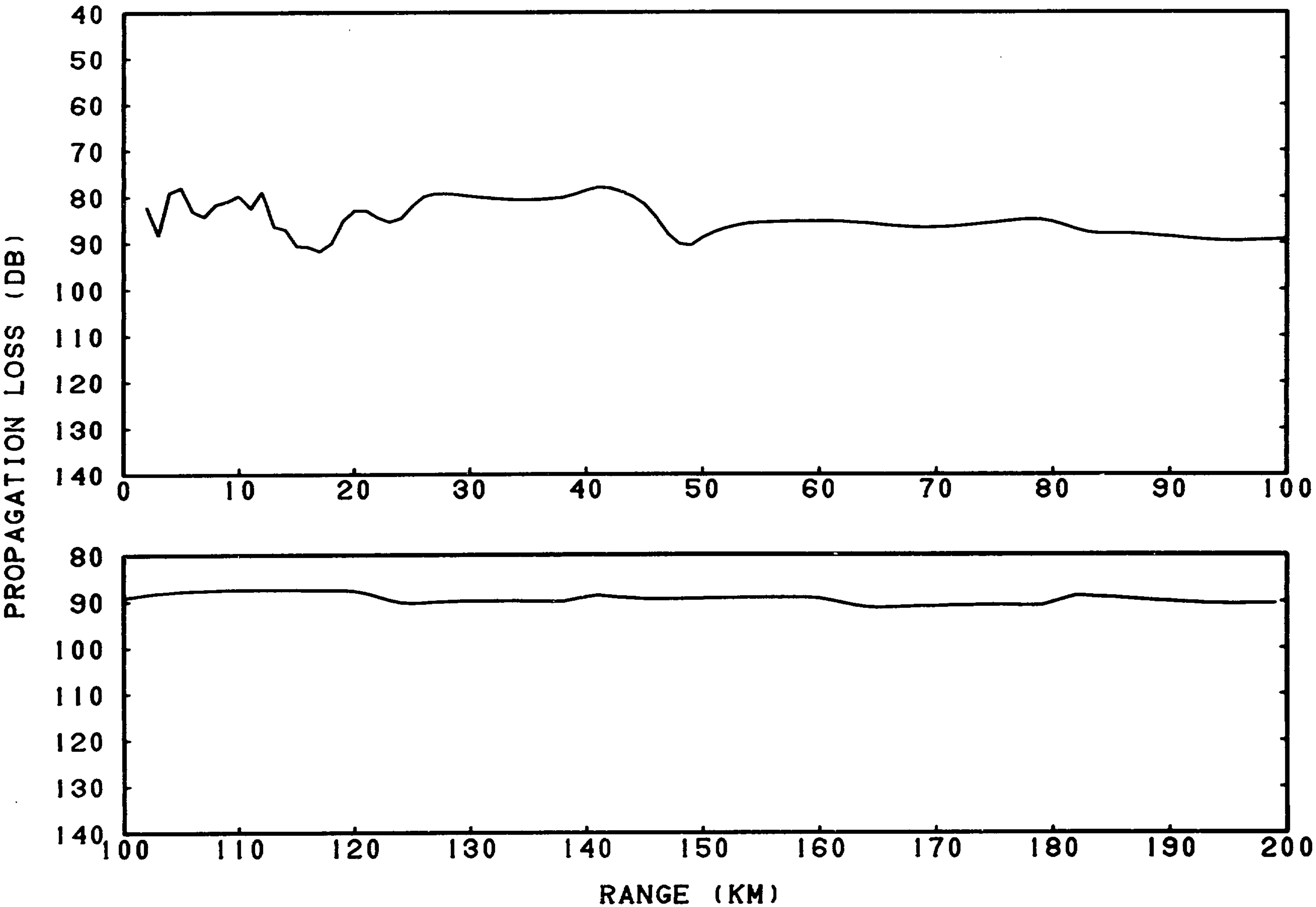
CONFIDENTIAL

(C) Figure IIB-21. FACT (Incoherent) Case II, Bottom Loss = FNOC Type 3, Frequency = 67.5 Hertz, Subtracted from Hays-Murphy Data, Case II, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 67.5 Hertz



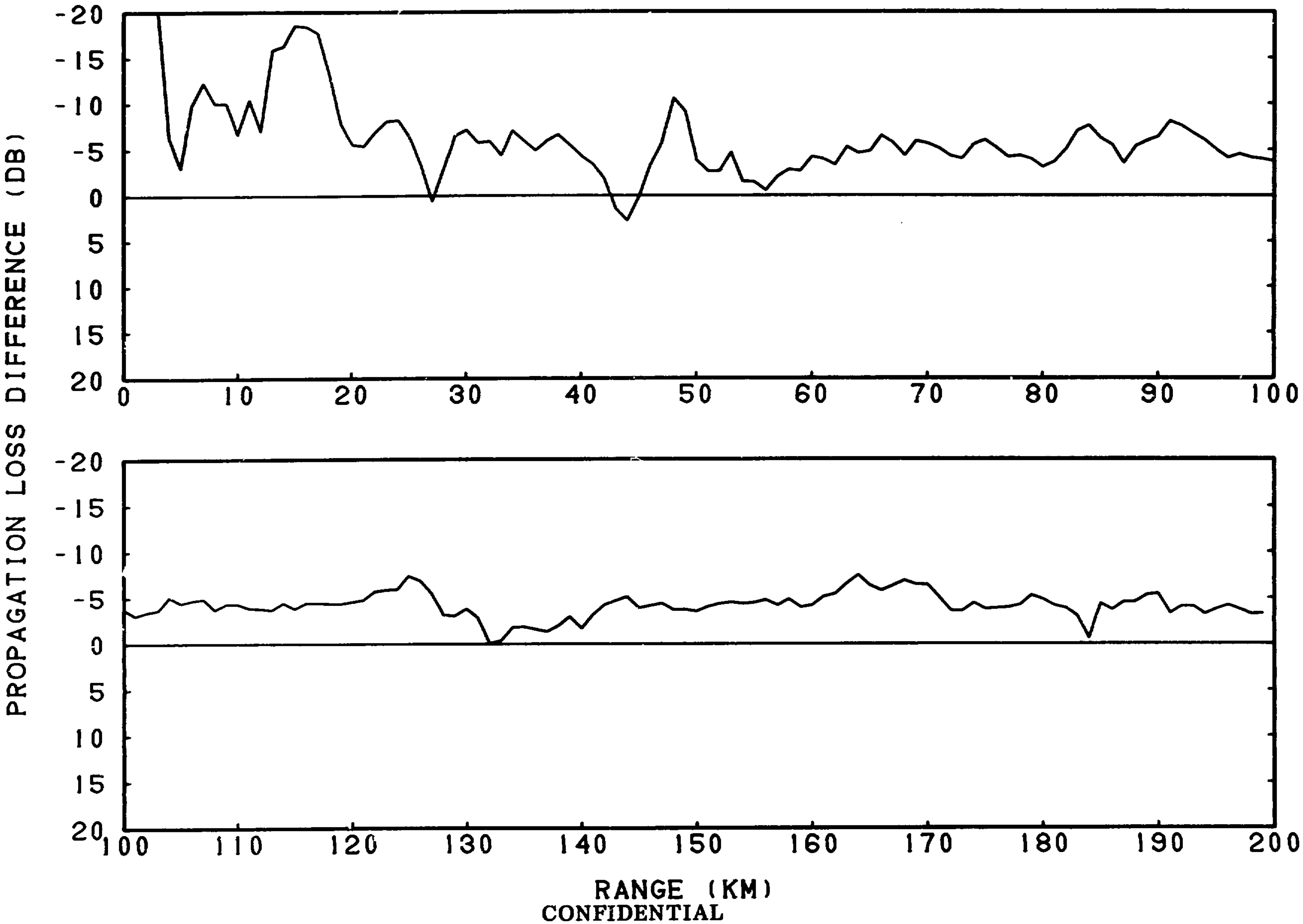
CONFIDENTIAL

(C) Figure IIB-22. FACT (Coherent) Case III, Bottom Loss = FNOC Type 3, Frequency = 100 Hertz

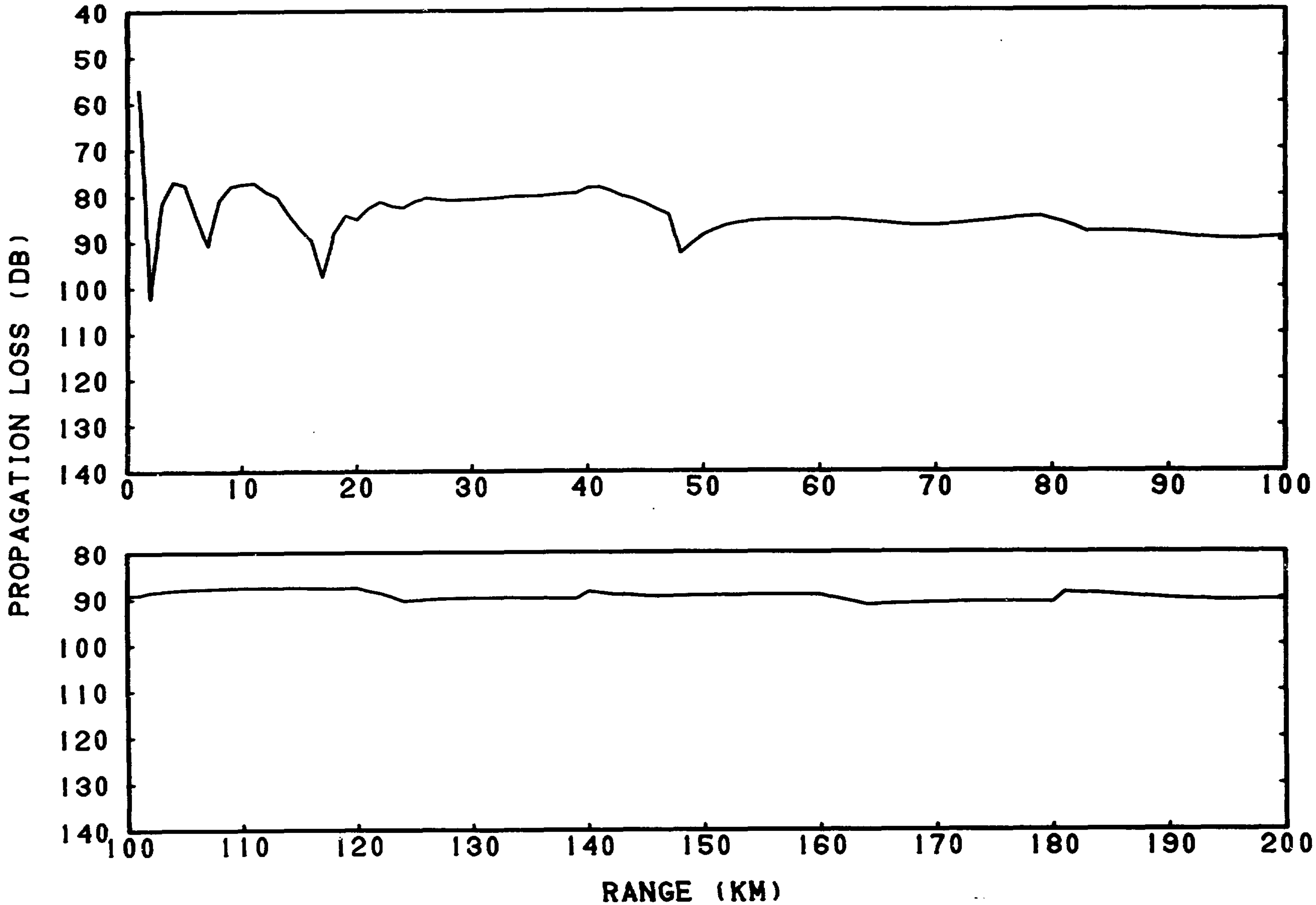


CONFIDENTIAL

(C) Figure IIB-23. FACT (Coherent) Case III, Bottom Loss = FNOC Type 3, Frequency = 100 Hertz, Sliding Averages of 3 Points (2.00 Kilometer)

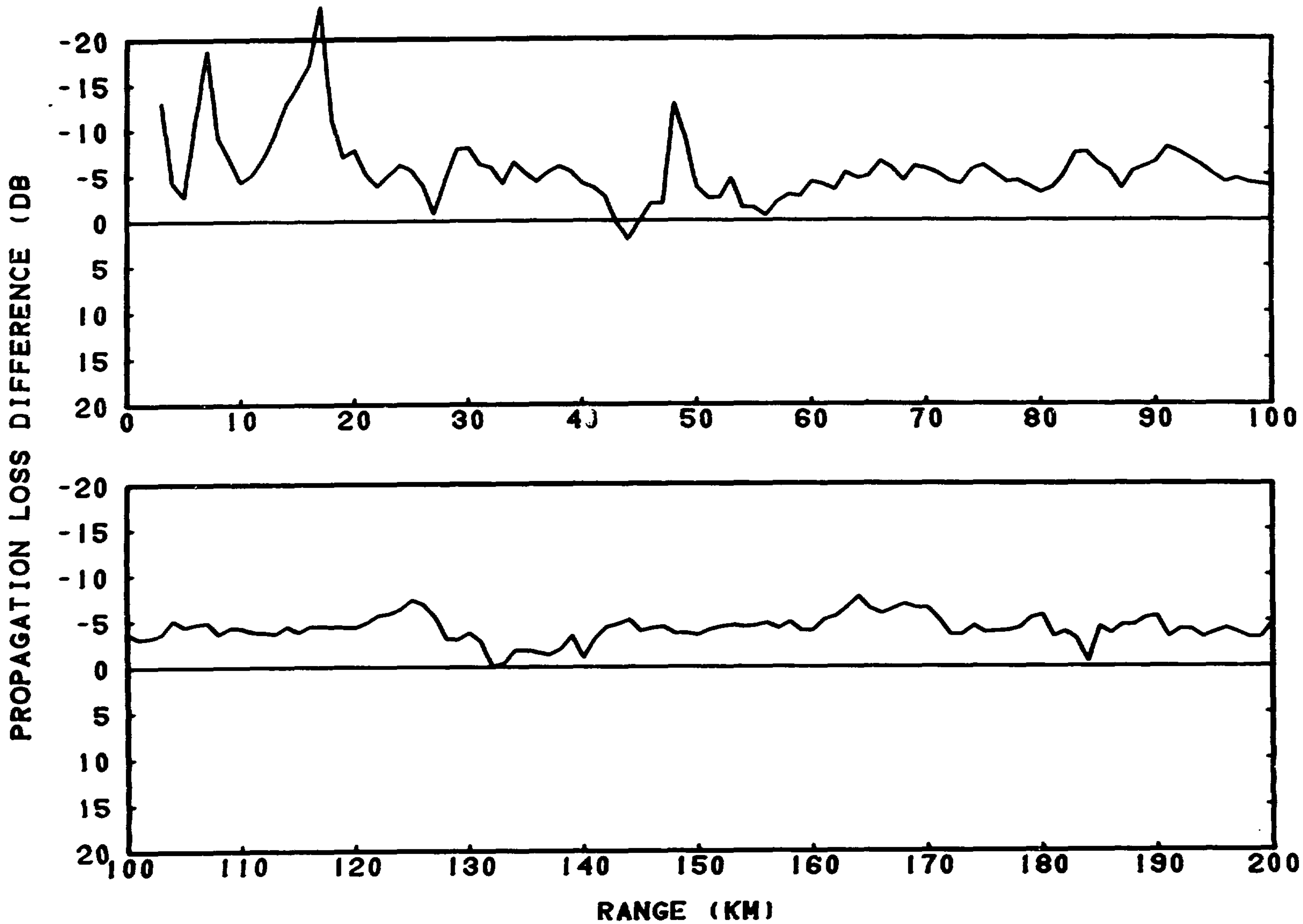


(C) Figure IIB-24. Smoothed FACT (Coherent) Case III, Bottom Loss = FNOC Type 3, Frequency = 100 Hertz, Subtracted from Hays-Murphy Data, Case III, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 100 Hertz



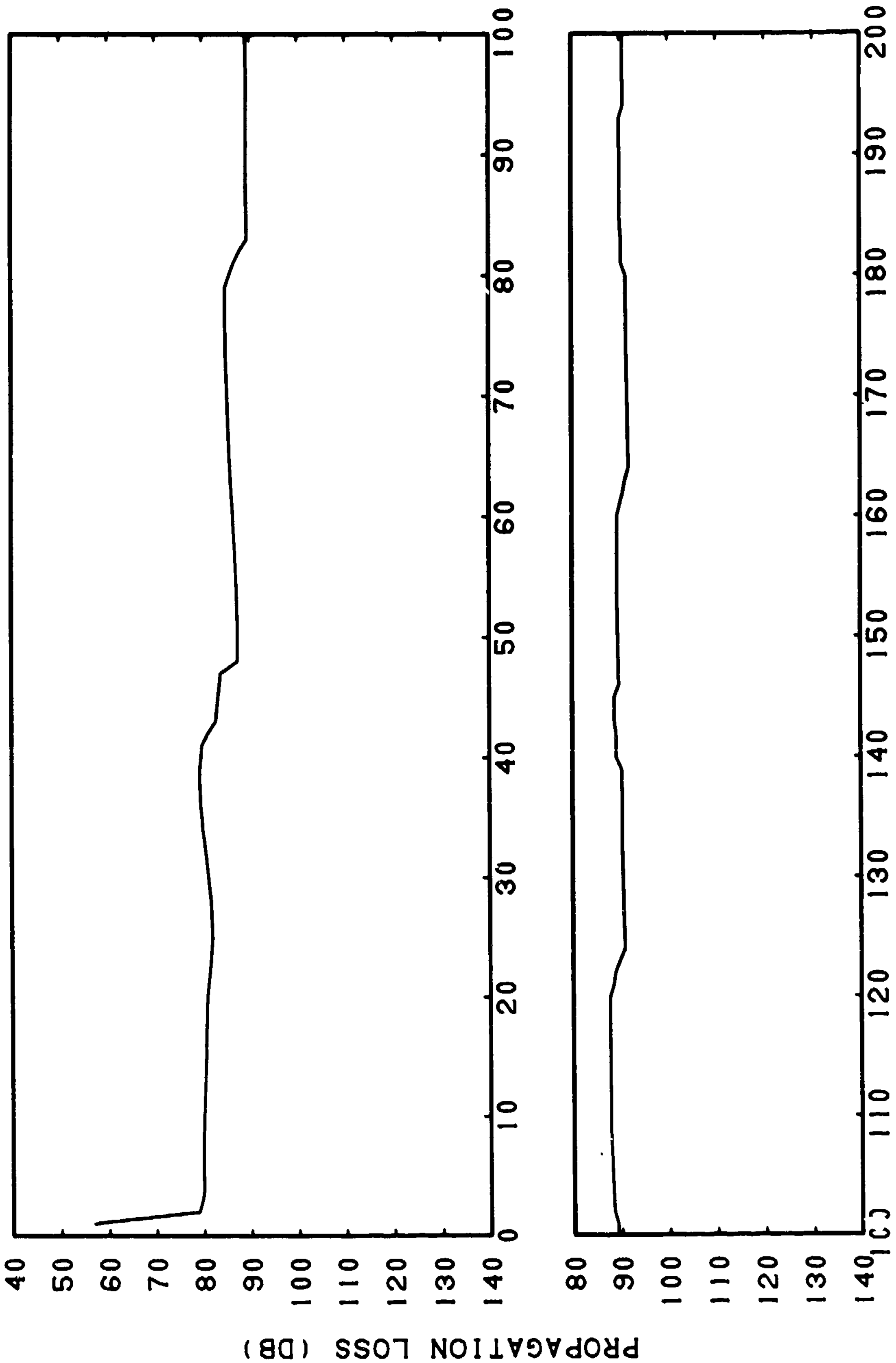
CONFIDENTIAL

(C) Figure IIB-25. FACT (Semi-coherent) Case III, Bottom Loss = FNOC Type 3, Frequency = 100 Hertz



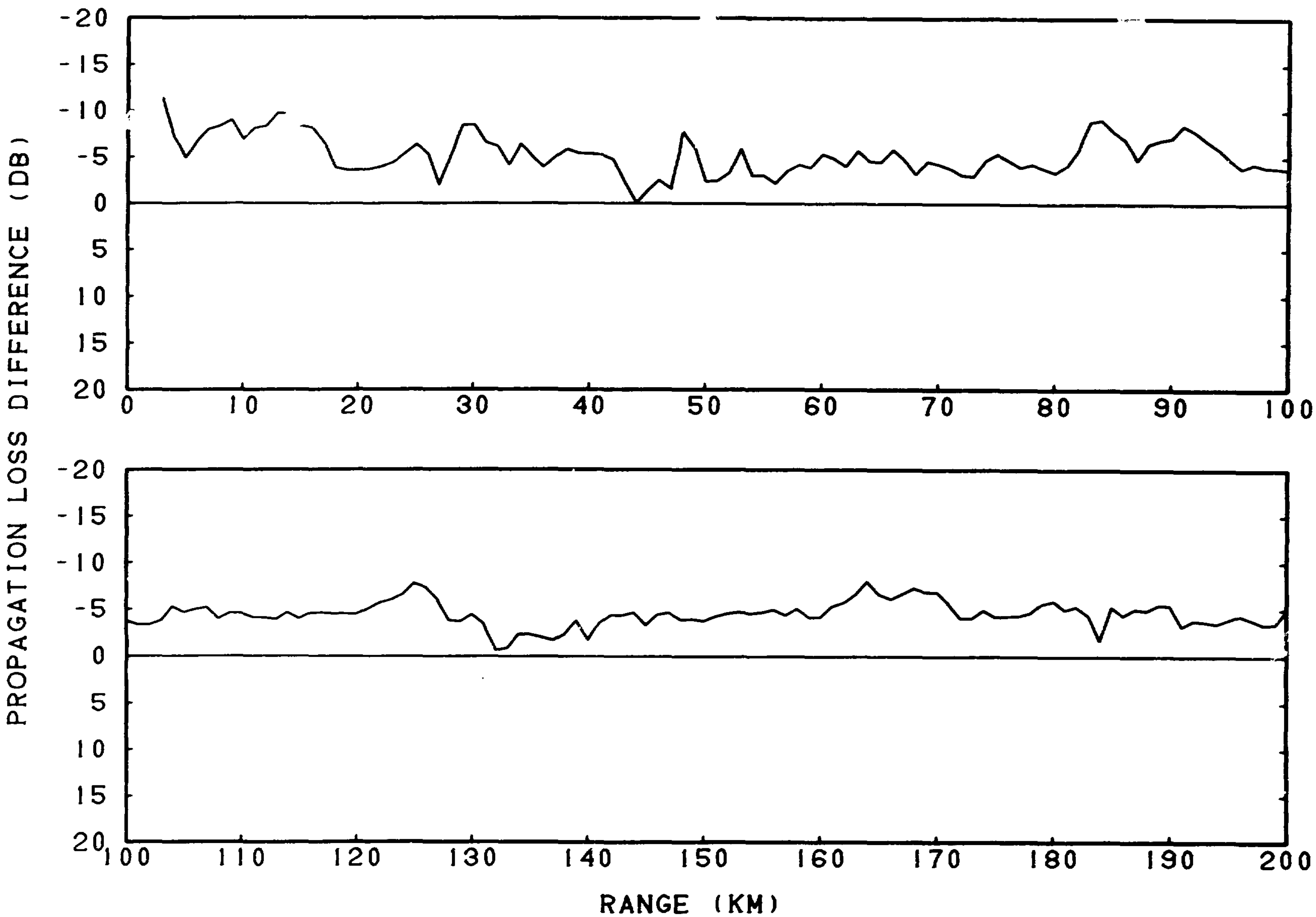
CONFIDENTIAL

(C) Figure IIB-26. FACT (Semi-coherent) Case III, Bottom Loss = FNOC Type 3, Frequency = 100 Hertz, Subtracted from Hays-Murphy Data, Case III, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 100 Hertz



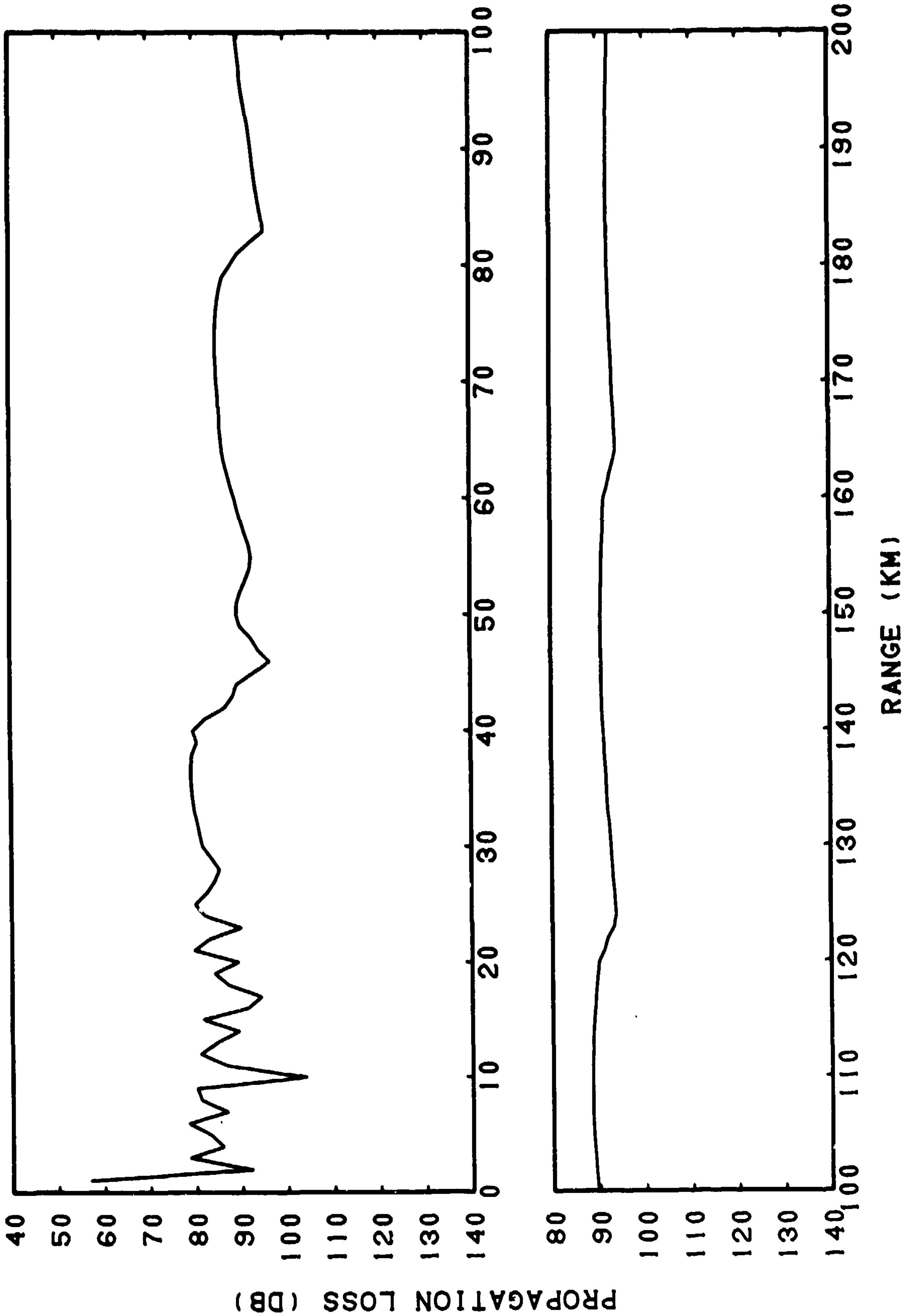
CONFIDENTIAL

(C) Figure IIB-27. FACT (Incoherent) Case III, Bottom Loss = FNOC Type 3, Frequency = 100 Hertz



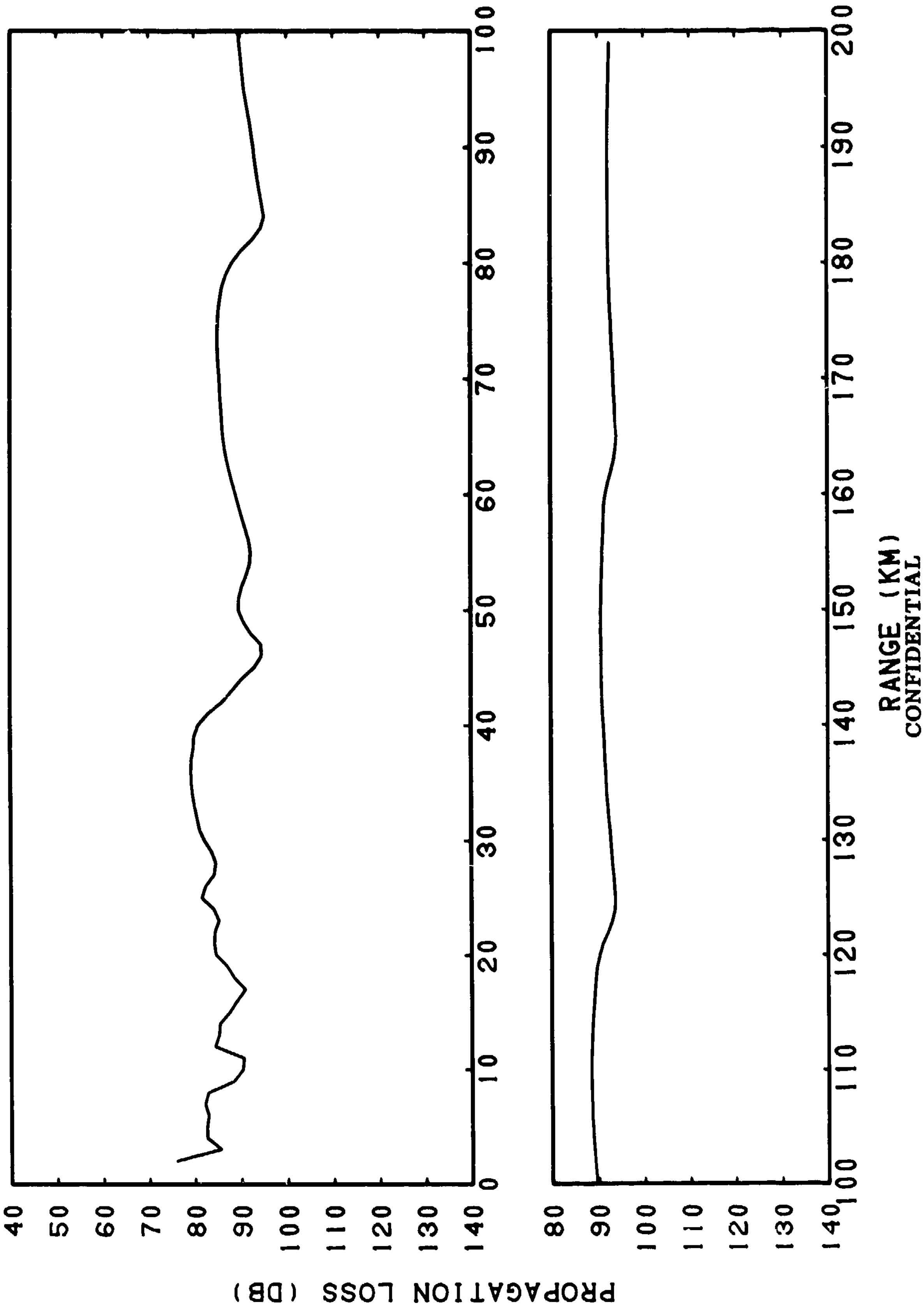
CONFIDENTIAL

(C) Figure IIB-28. FACT (Incoherent) Case III, Bottom Loss = FNOC Type 3, Frequency = 100 Hertz, Subtracted from Hays-Murphy Data, Case III, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 100 Hertz

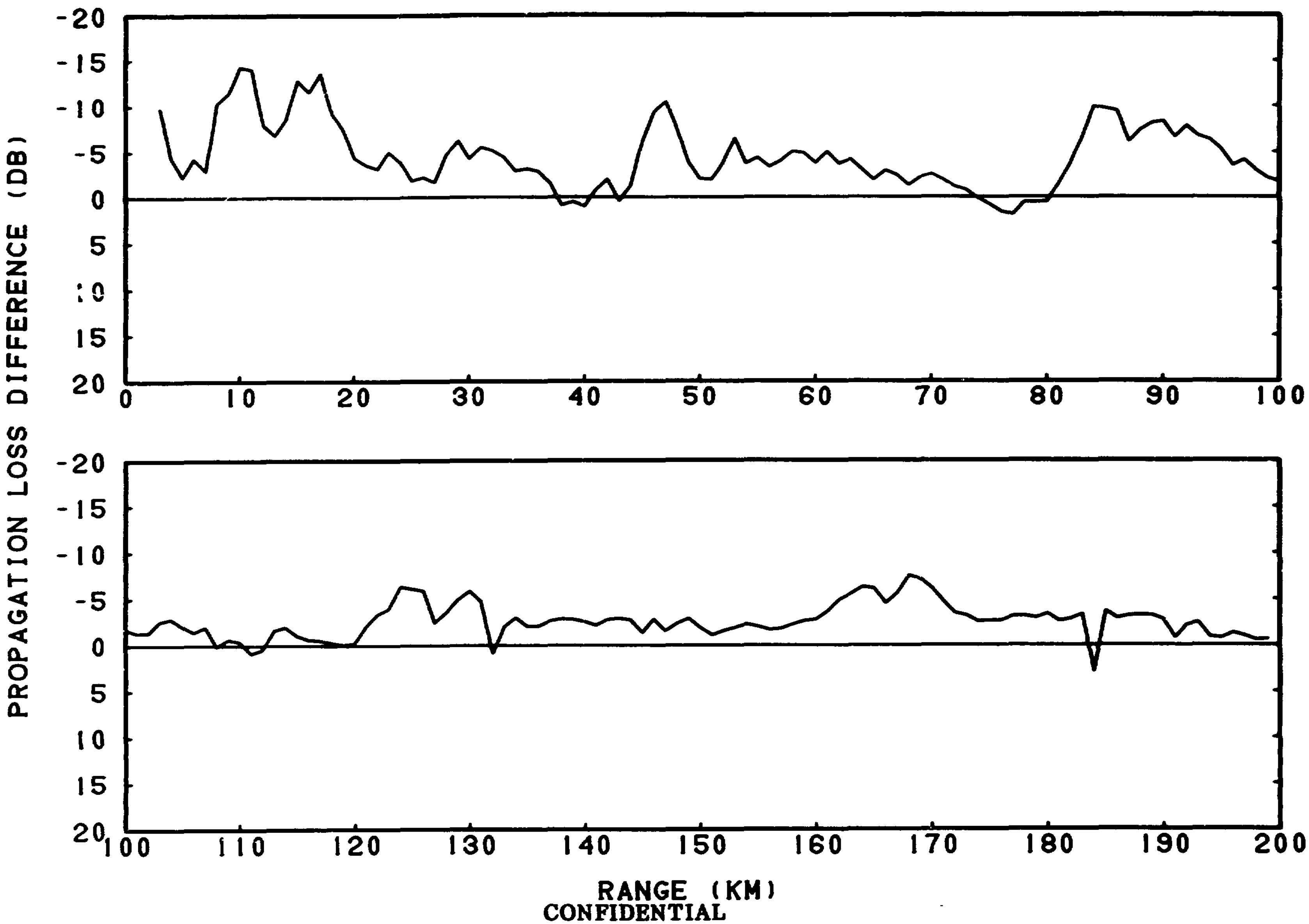


CONFIDENTIAL

(C) Figure IIB-29. FACT (Coherent) Case IV, Bottom Loss = FNOC Type 3, Frequency = 200 Hertz

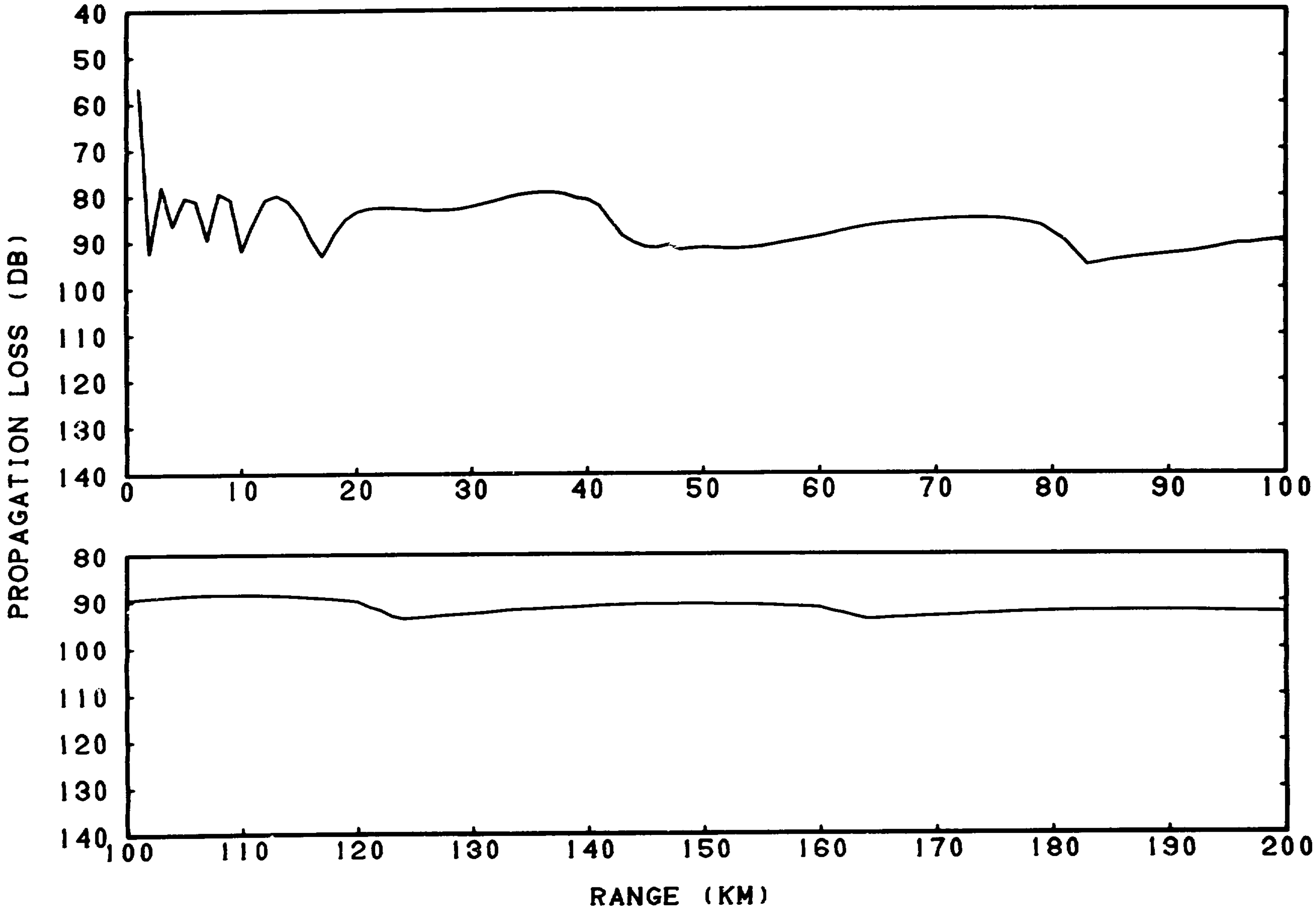


(C) Figure IIB-30. FACT (Coherent) Case IV, Bottom Loss = FNOC Type 3, Frequency = 200 Hertz, Sliding Averages of 3 Points (2.00 Kilometer)



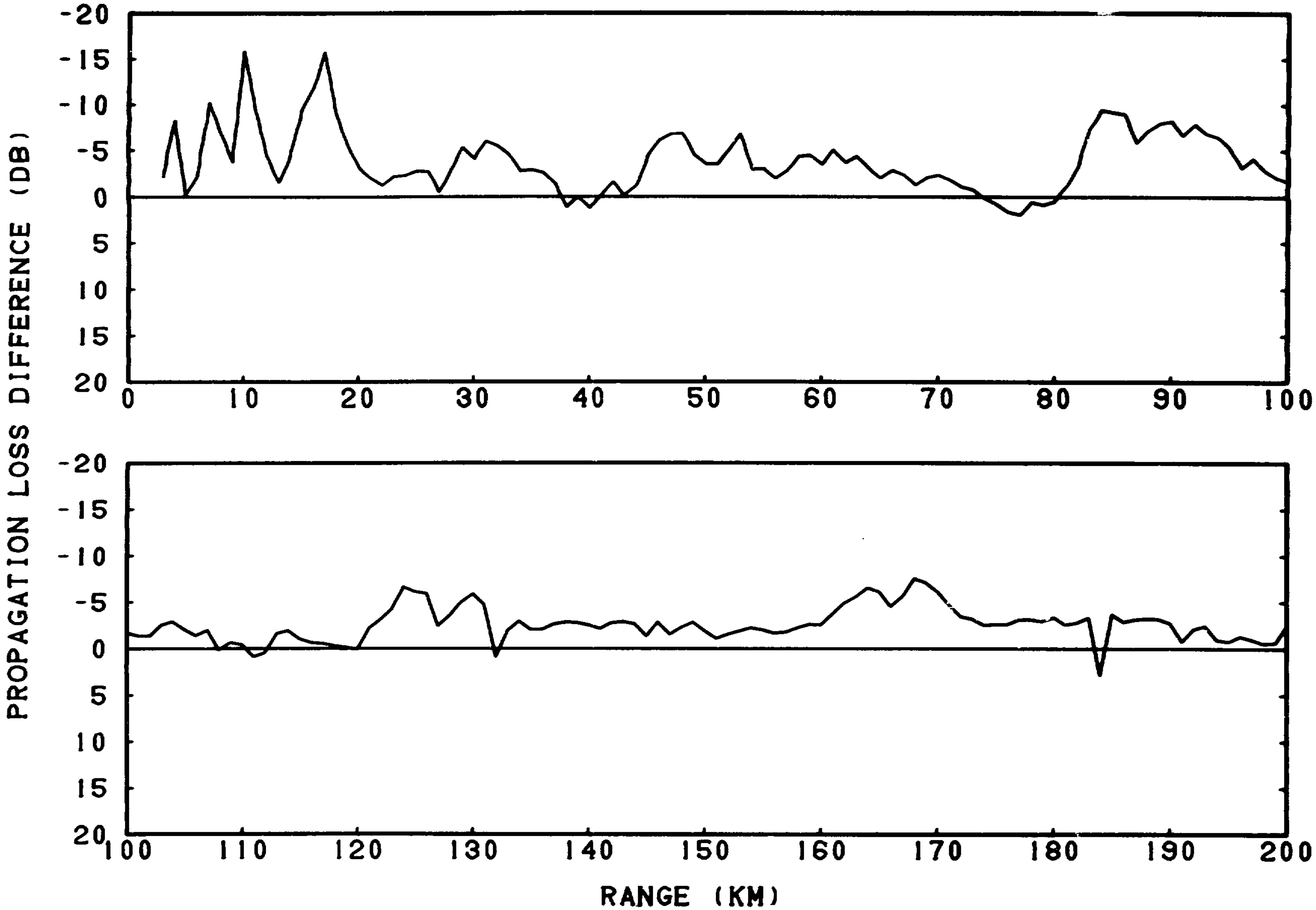
CONFIDENTIAL

(C) Figure IIB-31. Smoothed FACT (Coherent) Case IV, Bottom Loss = FNOC Type 3, Frequency = 200 Hertz, Subtracted from Hays-Murphy Data, Case IV, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 200 Hertz



CONFIDENTIAL

(C) Figure IIB-32. FACT (Semi-coherent) Case IV, Bottom Loss = FNOC Type 3, Frequency = 200 Hertz

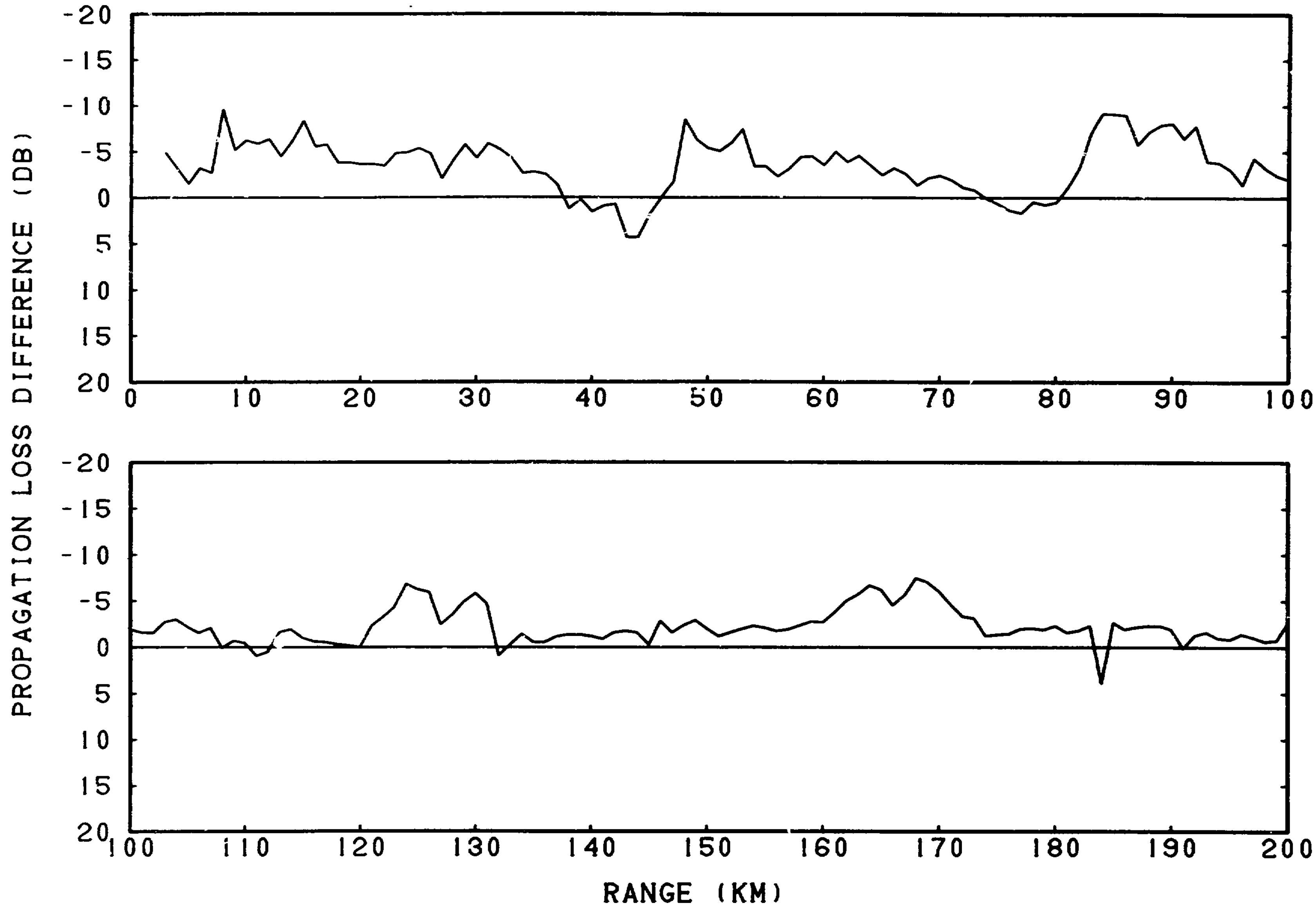


CONFIDENTIAL

(C) Figure IIB-33. FACT (Semi-coherent) Case IV, Bottom Loss = FNOC Type 3, Frequency = 200 Hertz, Subtracted from Hays-Murphy Data, Case IV, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 200 Hertz

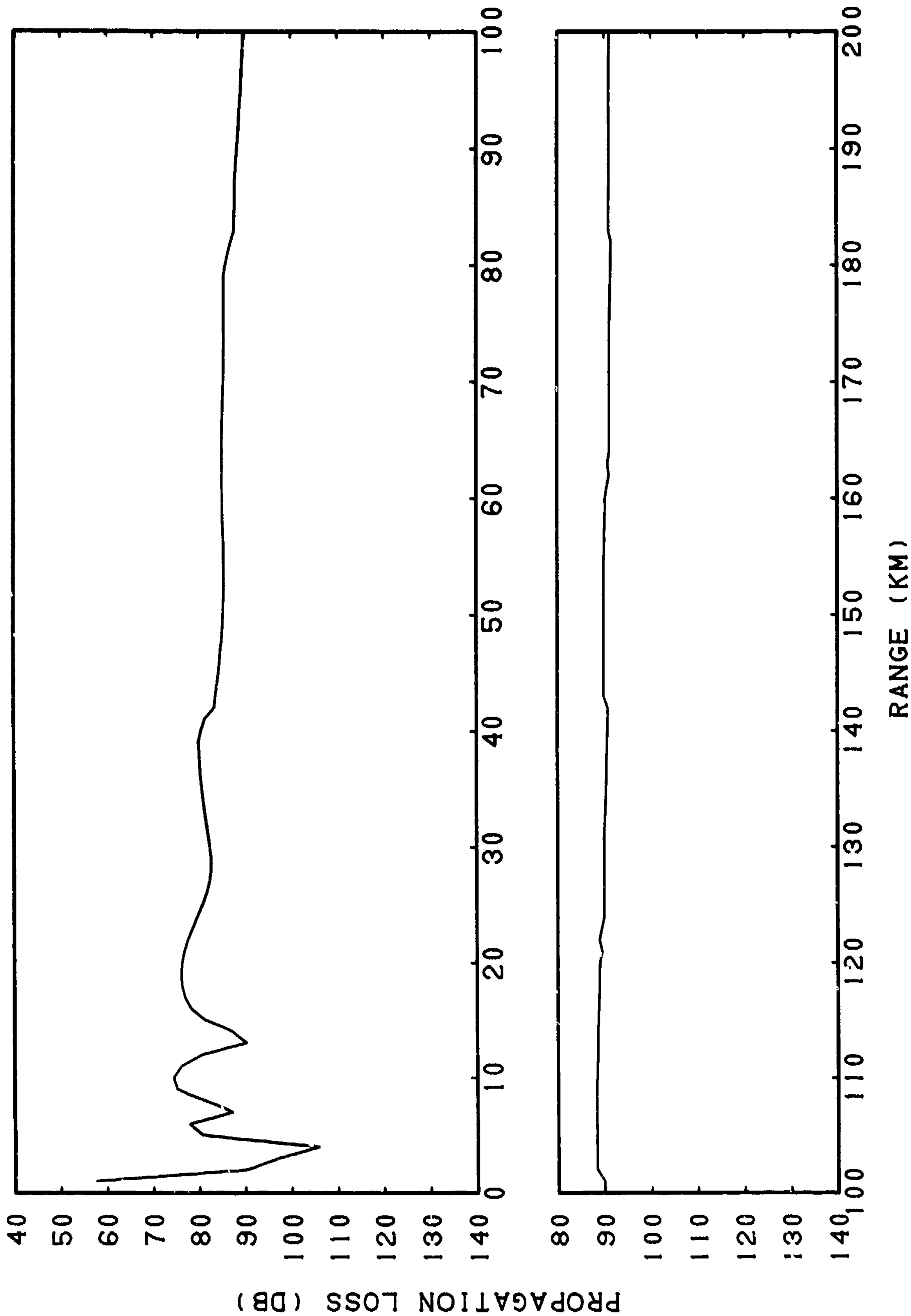
CONFIDENTIAL

(C) Figure IIB-34. FACT (Incoherent) Case IV, Bottom Loss = FNOC Type 3, Frequency = 200 Hertz



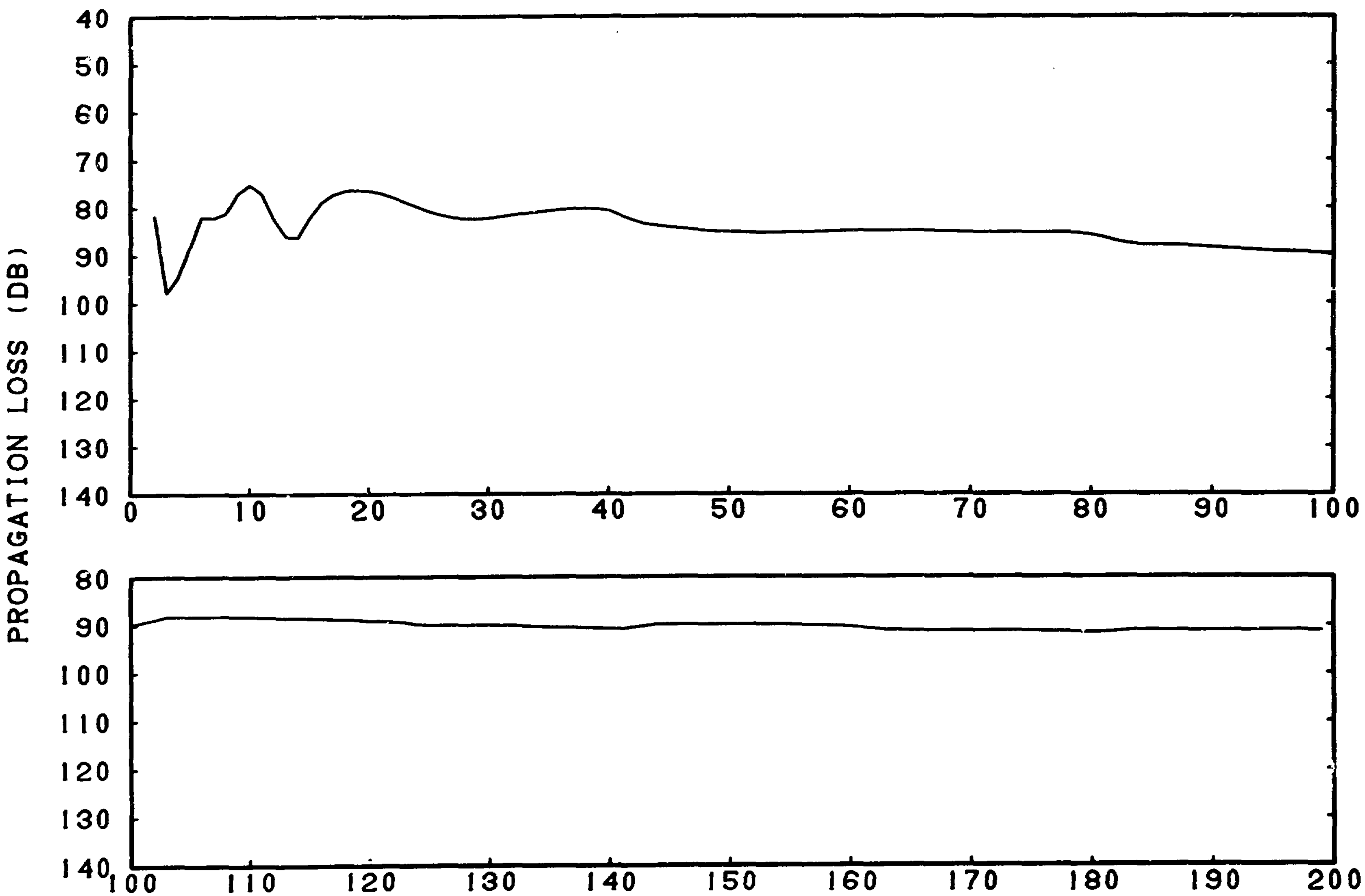
CONFIDENTIAL

(C) Figure IIB-35. FACT (Incoherent) Case IV, Bottom Loss = FNOC Type 3, Frequency = 200 Hertz, Subtracted from Hays-Murphy Data, Case IV, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 200 Hertz



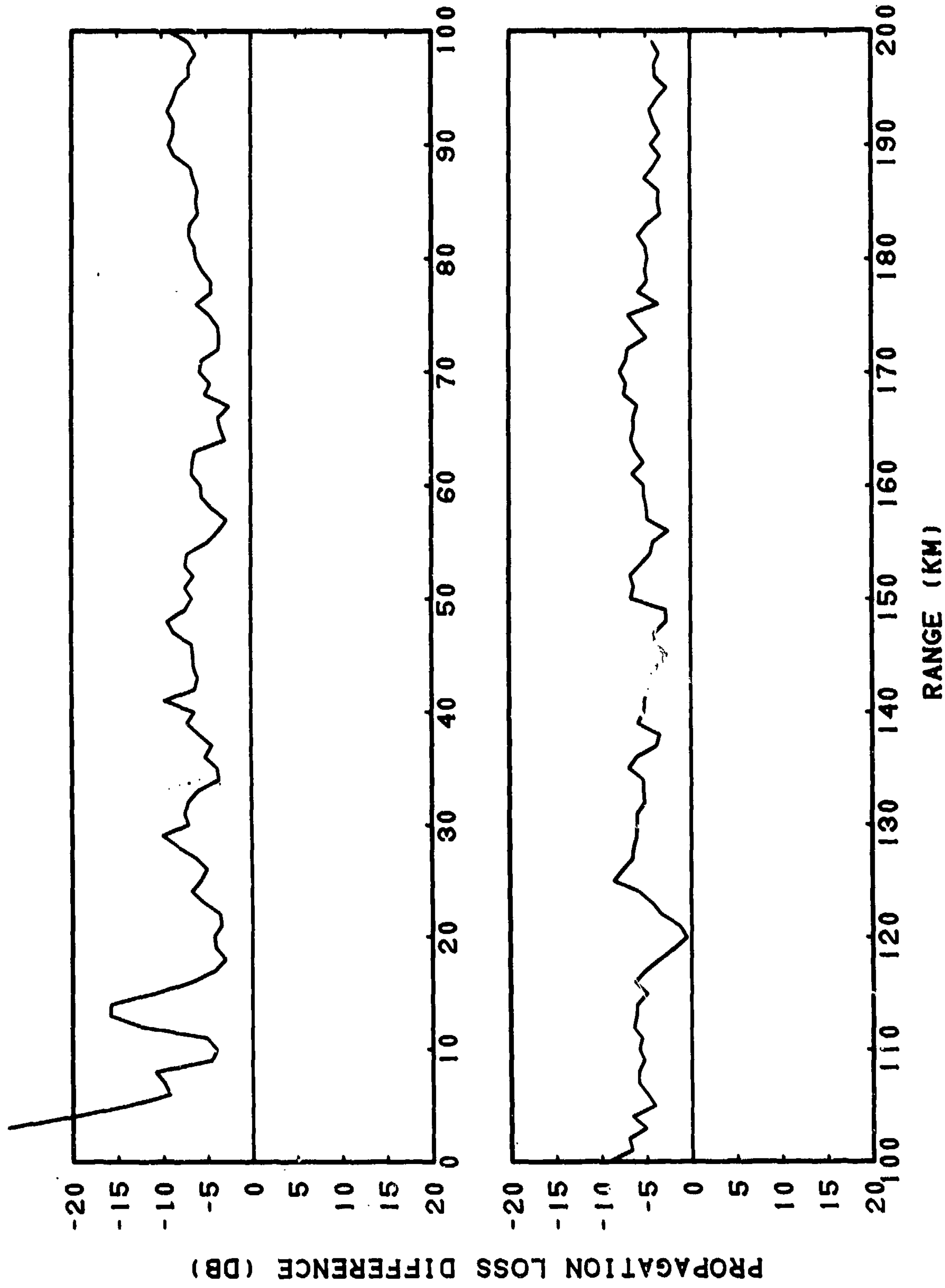
CONFIDENTIAL

(C) Figure IIB-36. FACT (Coherent) Case V, Bottom Loss = FNOC Type 3, Frequency = 35 Hertz



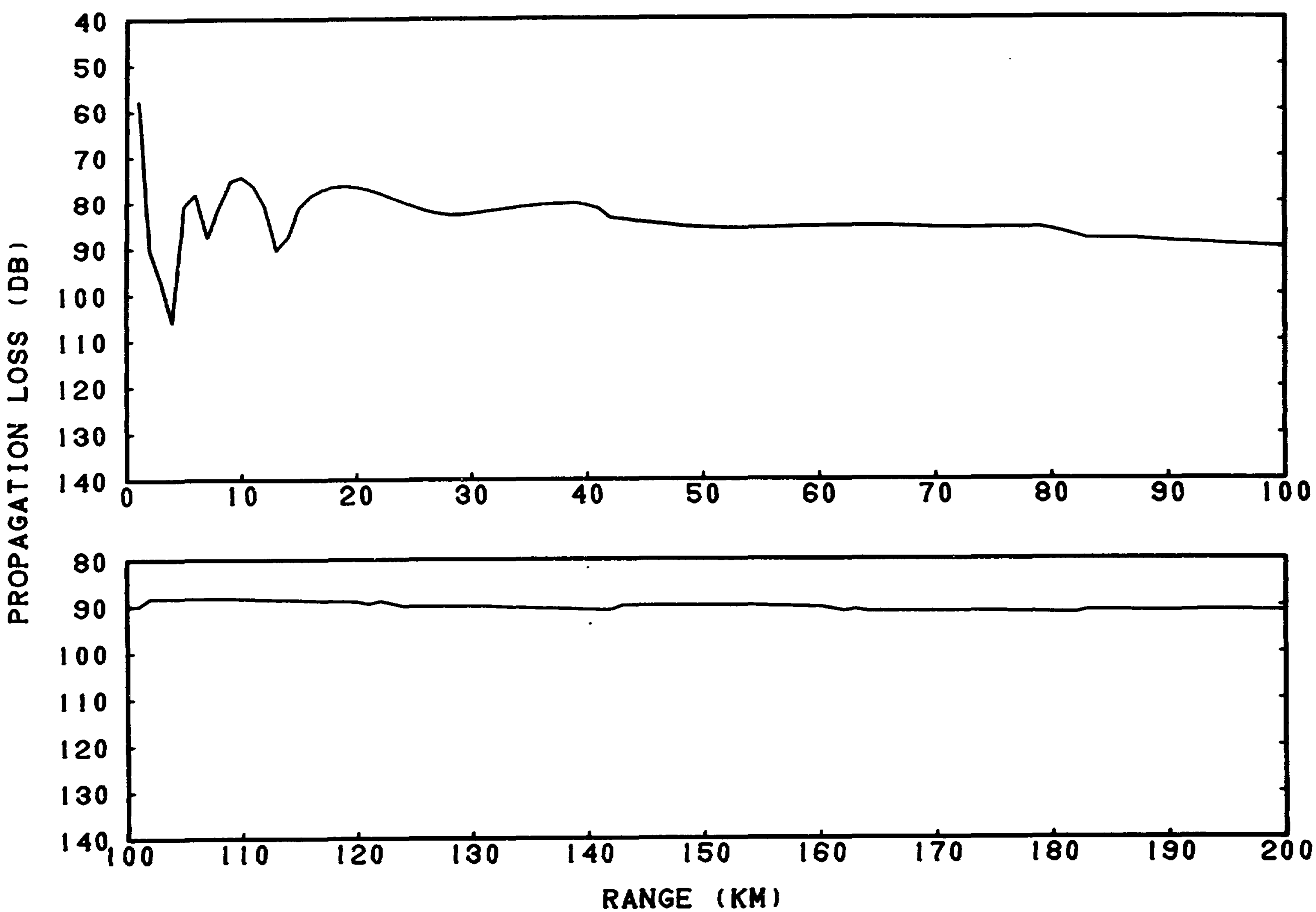
CONFIDENTIAL

(C) Figure IIB-37. FACT (Coherent) Case V, Bottom Loss = FNOC Type 3, Frequency = 35 Hertz, Sliding Averages of 3 Points (2.00 Kilometer)



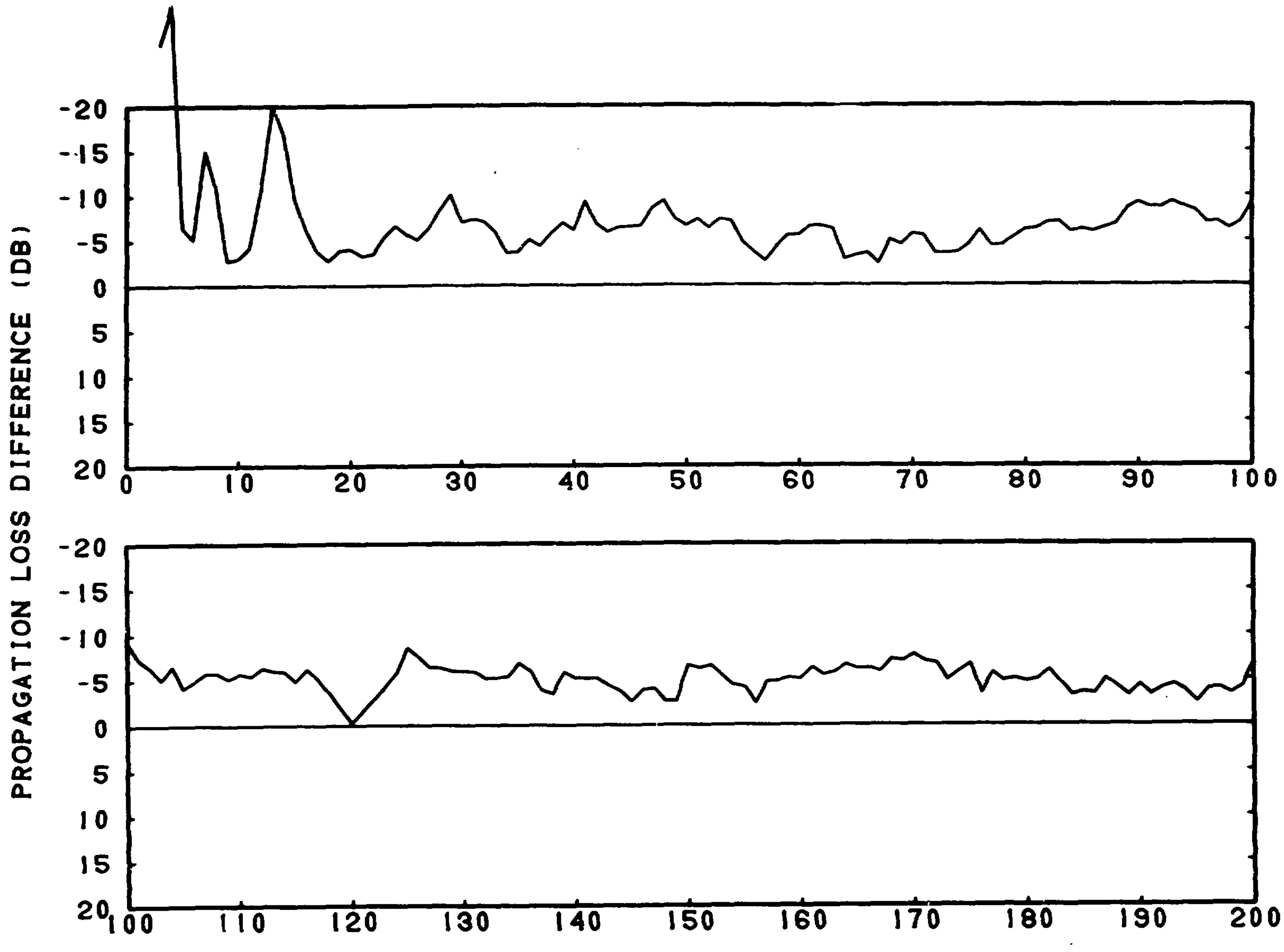
CONFIDENTIAL

(C) Figure IIB-38. Smoothed FACT (Coherent) Case V, Bottom Loss = FNOC Type 3, Frequency = 35 Hertz, Subtracted from Hays-Murphy Data, Case V, Source Depth = 80 Feet, Receiver Depth = 350 Feet, Frequency = 35 Hertz



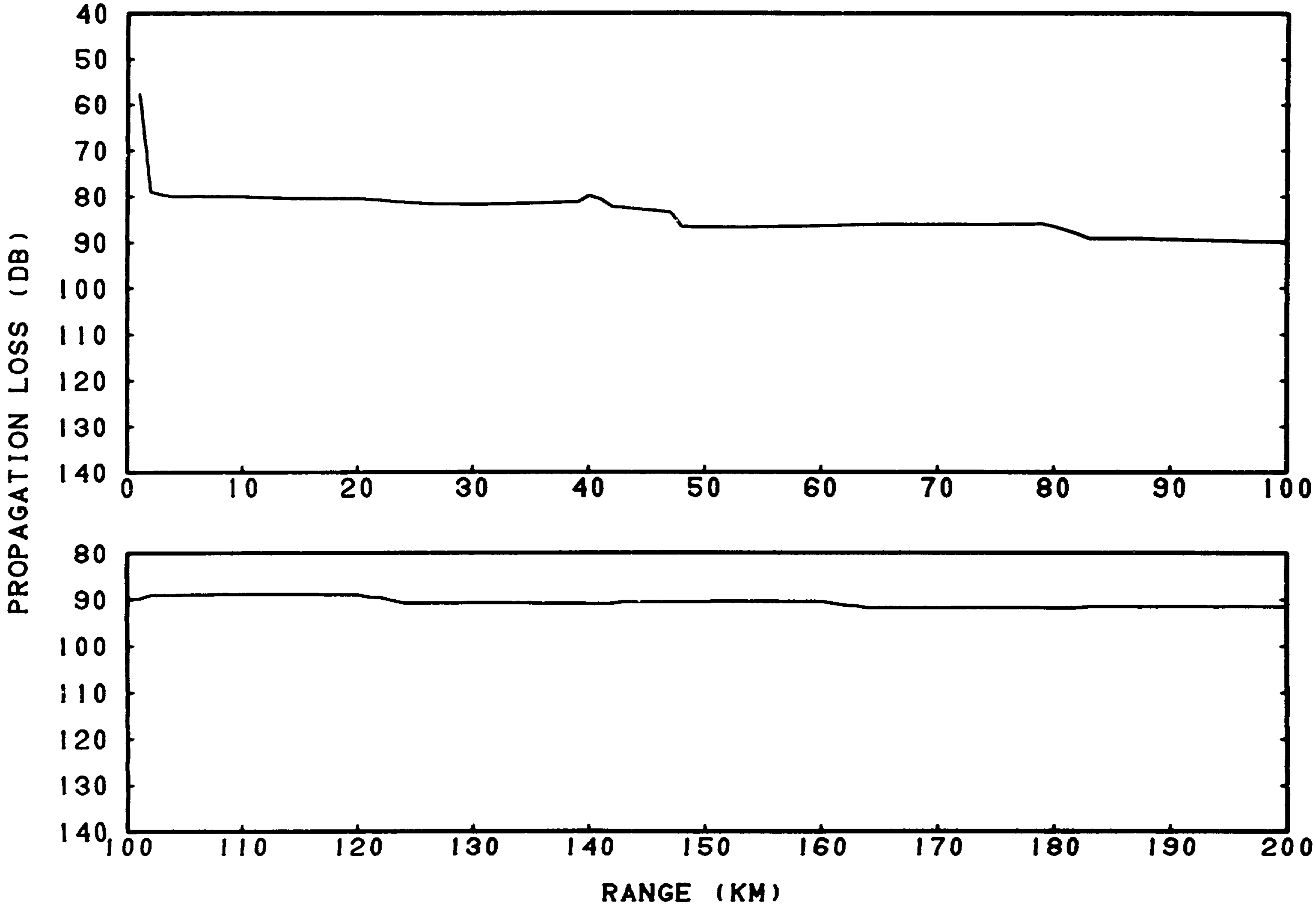
CONFIDENTIAL

(C) Figure IIB-39. FACT (Semi-coherent) Case V, Bottom Loss = FNOC Type 3, Frequency = 35 Hertz



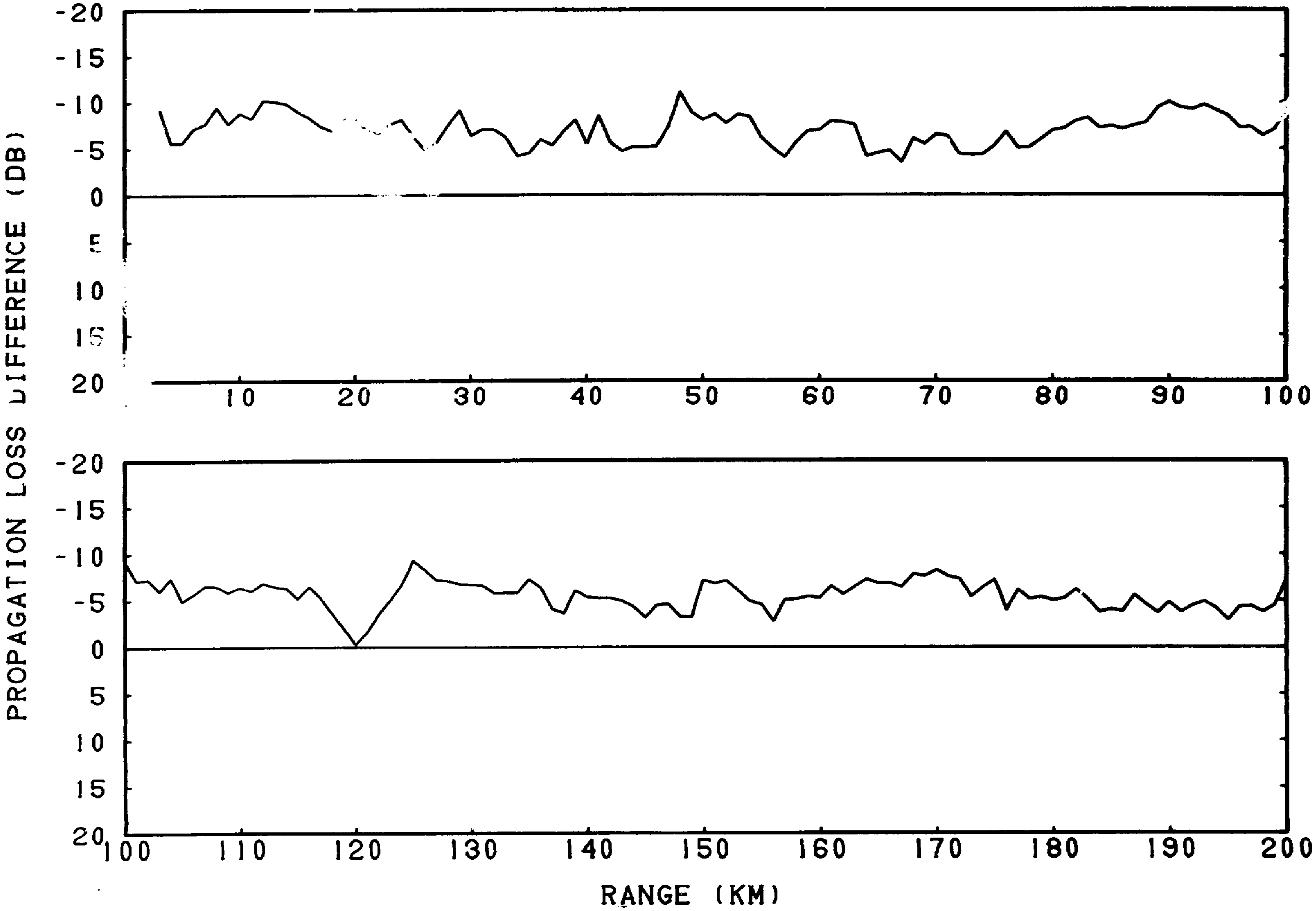
CONFIDENTIAL

(C) Figure IIB-40. FACT (Semi-coherent) Case V, Bottom Loss = FNOC Type 3, Frequency = 35 Hertz, Subtracted from Hays-Murphy Data, Case V, Source Depth = 80 Feet, Receiver Depth = 350 Feet, Frequency = 35 Hertz



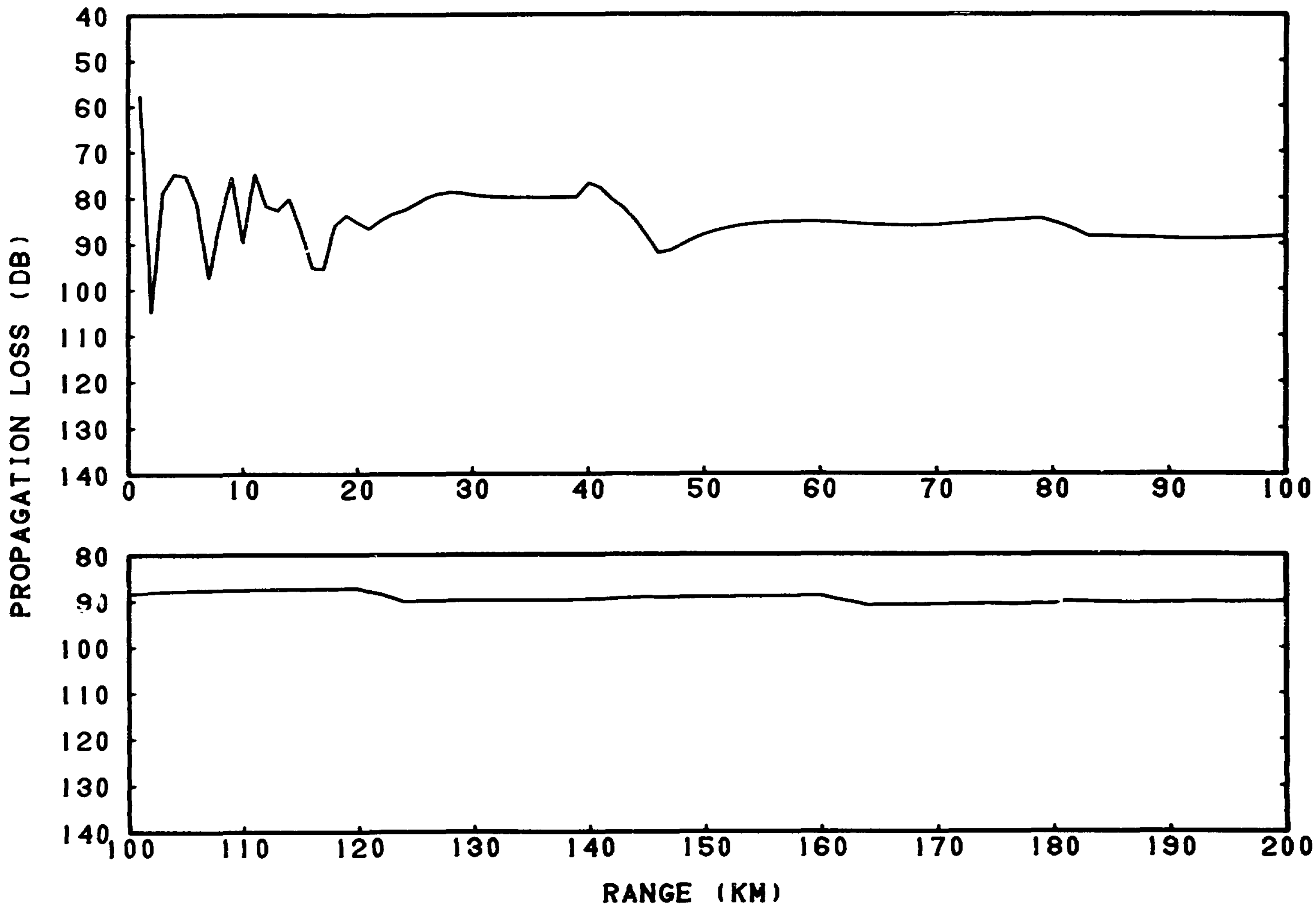
CONFIDENTIAL

(C) Figure IIB-41. FACT (Incoherent) Case V, Bottom Loss = FNOC Type 3, Frequency = 35 Hertz



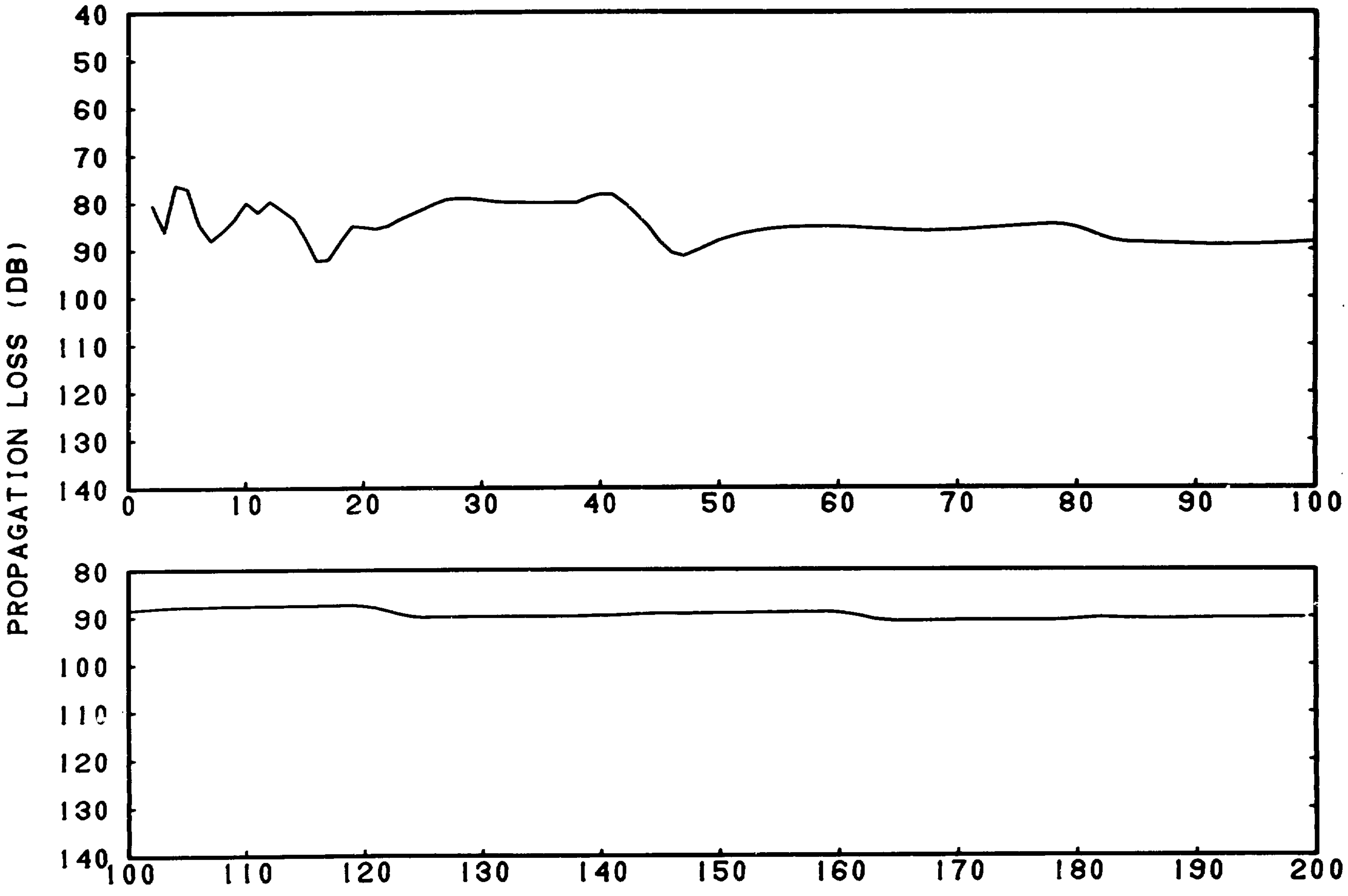
CONFIDENTIAL

(C) Figure IIB-42. FACT (Incoherent) Case V, Bottom Loss = FNOC Type 3, Frequency = 35 Hertz, Subtracted from Hays-Murphy Data, Case V, Source Depth = 80 Feet, Receiver Depth = 350 Feet, Frequency = 35 Hertz



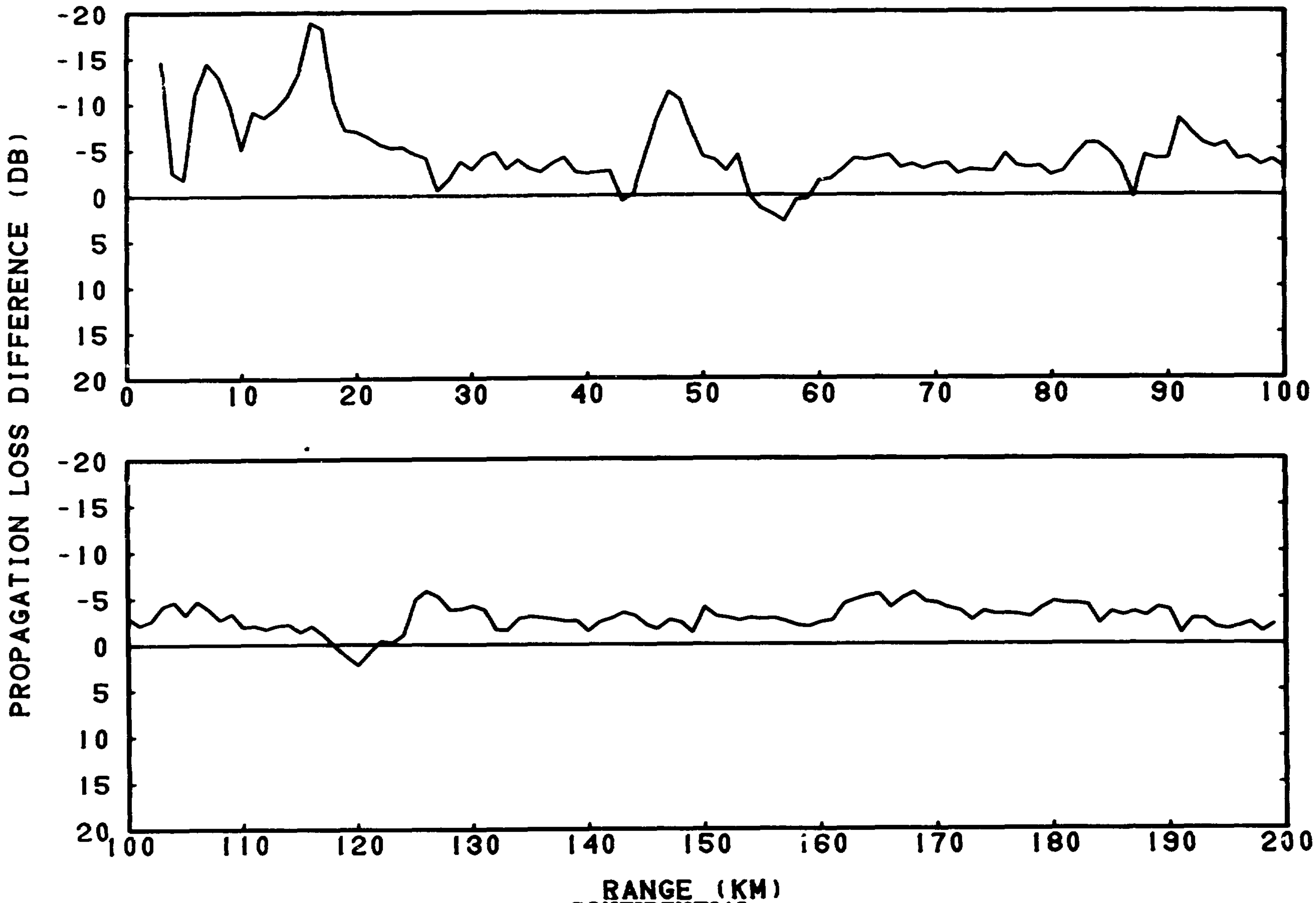
CONFIDENTIAL

(C) Figure IIB-43. FACT (Coherent) Case VI, Bottom Loss = FNOC Type 3, Frequency = 100 Hertz



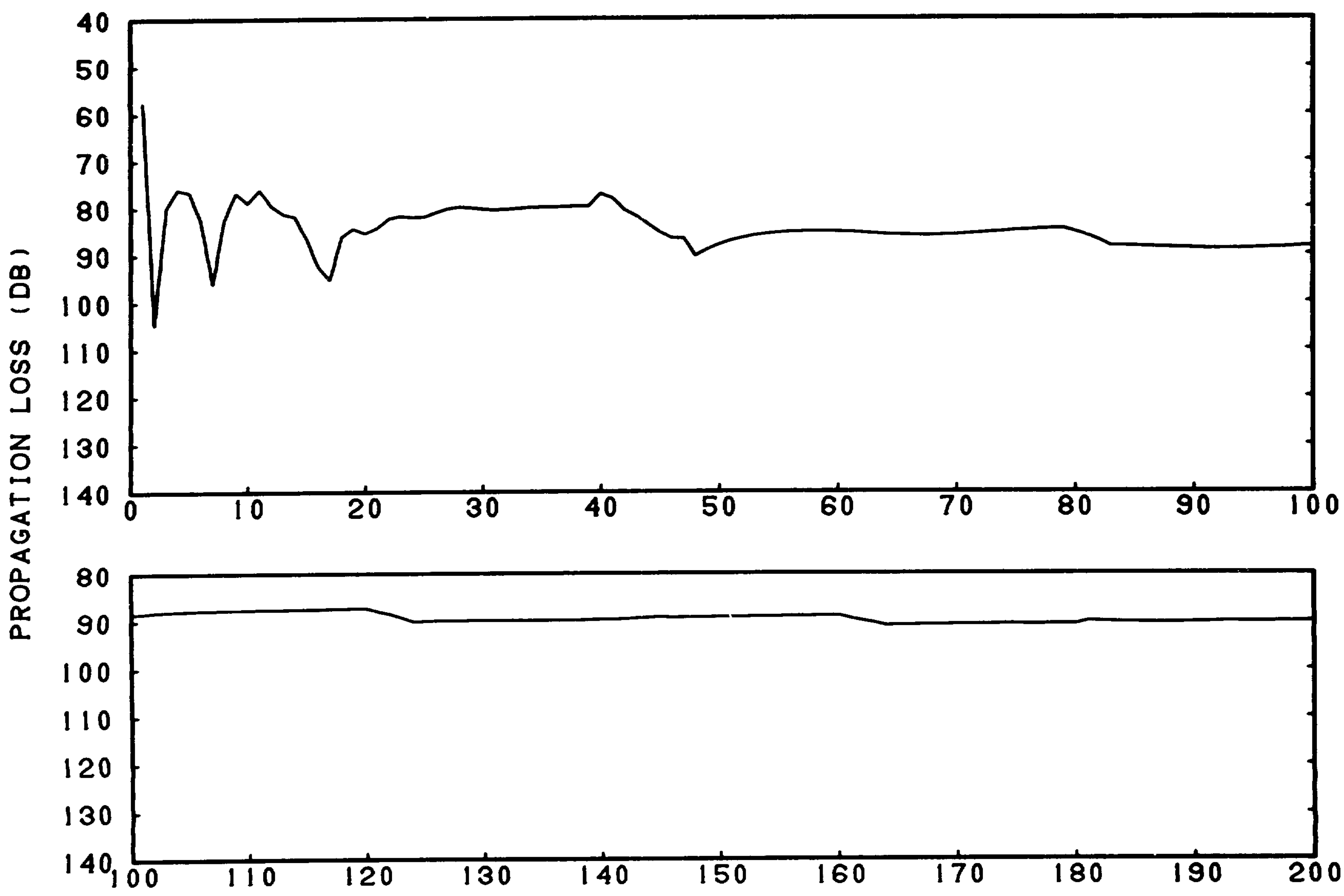
CONFIDENTIAL

(C) Figure IIB-44. FACT (Coherent) Case VI, Bottom Loss = FNOC Type 3, Frequency = 100 Hertz, Sliding Averages of 3 Points (2.00 Kilometer)



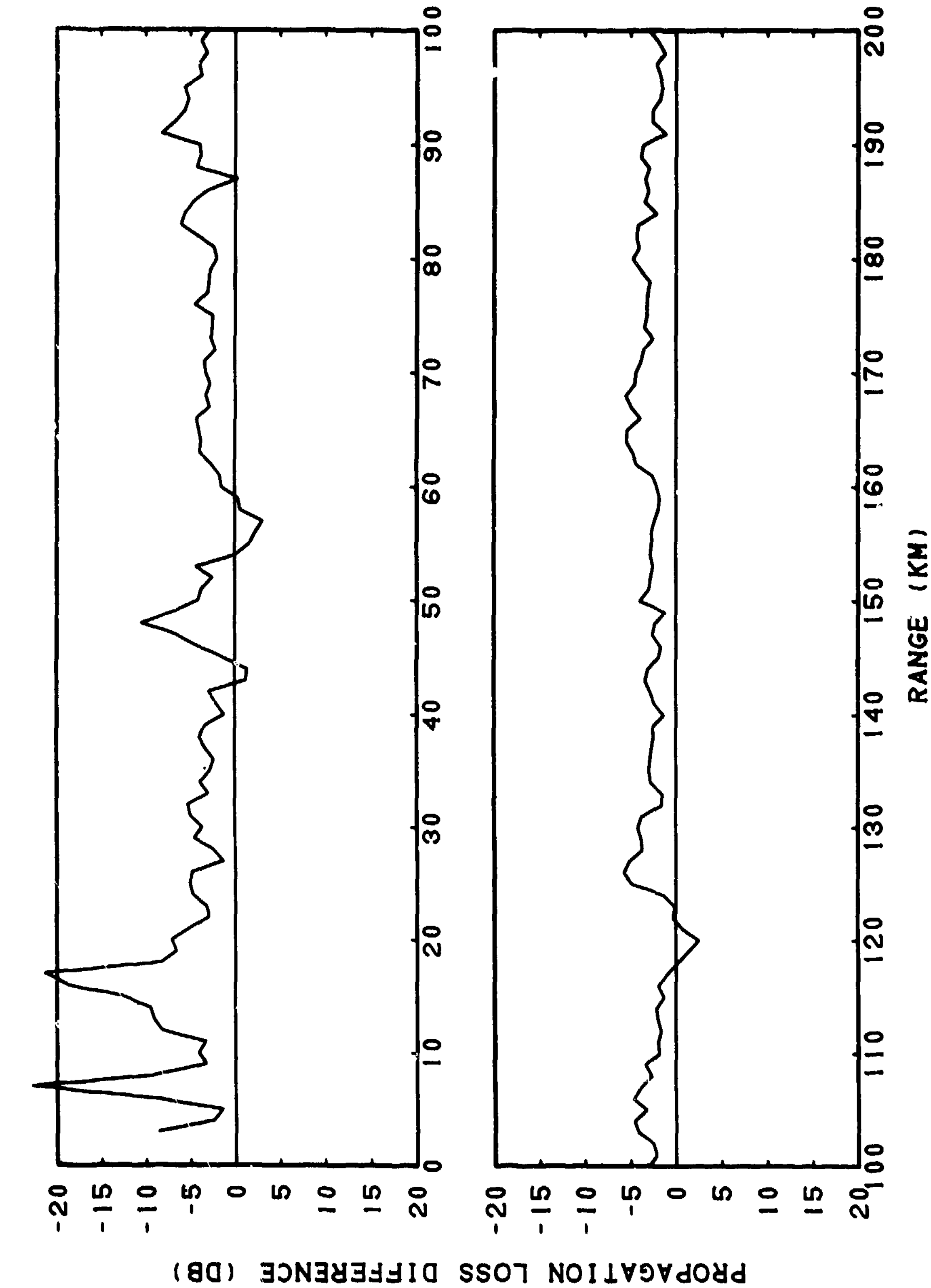
CONFIDENTIAL

(C) Figure IIB-45. Smoothed FACT (Coherent) Case VI, Bottom Loss = FNOC Type 3, Frequency = 100 Hertz, Subtracted from Hays-Murphy Data, Case VI, Source Depth = 80 Feet, Receiver Depth = 350 Feet, Frequency = 100 Hertz



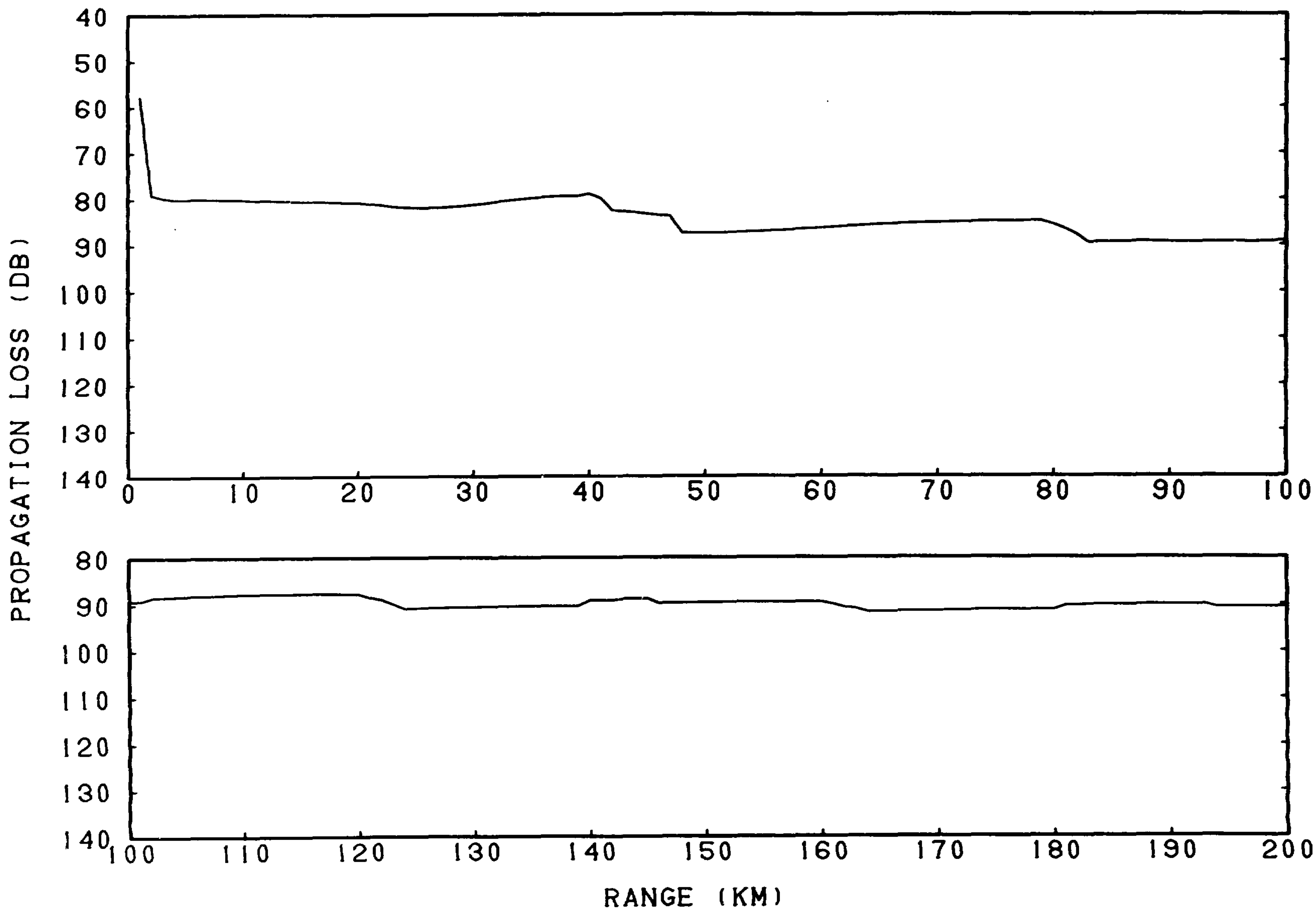
CONFIDENTIAL

(C) Figure IIB-46. FACT (Semi-coherent) Case VI, Bottom Loss = FNOC Type 3, Frequency = 100 Hertz



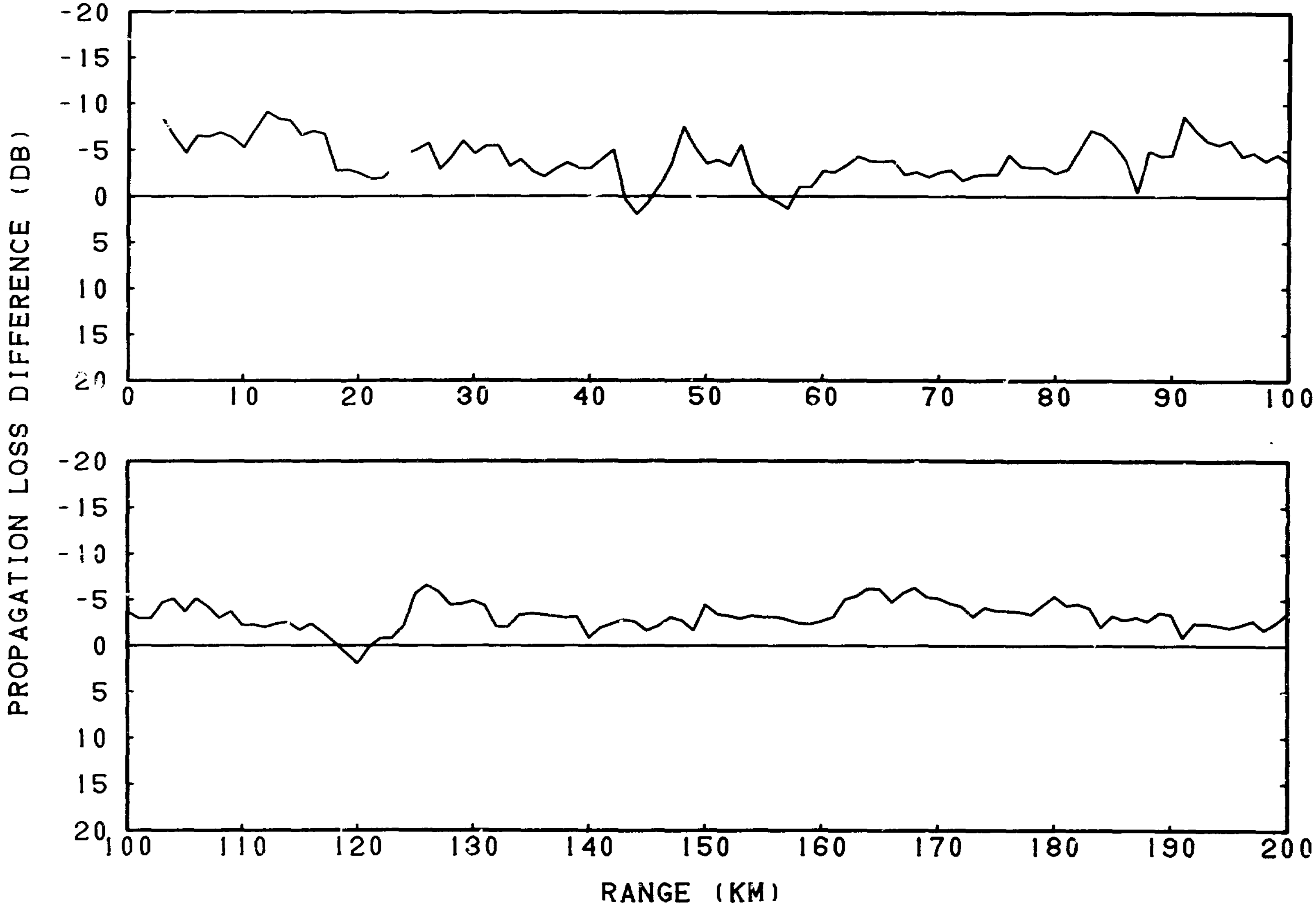
CONFIDENTIAL

(C) Figure IIB-47. FACT (Semi-coherent) Case VI, Bottom Loss = FNOC Type 3, Frequency = 100 Hertz, Subtracted from Hays-Murphy Data, Case VI, Source Depth = 80 Feet, Receiver Depth = 350 Feet, Frequency = 100 Hertz



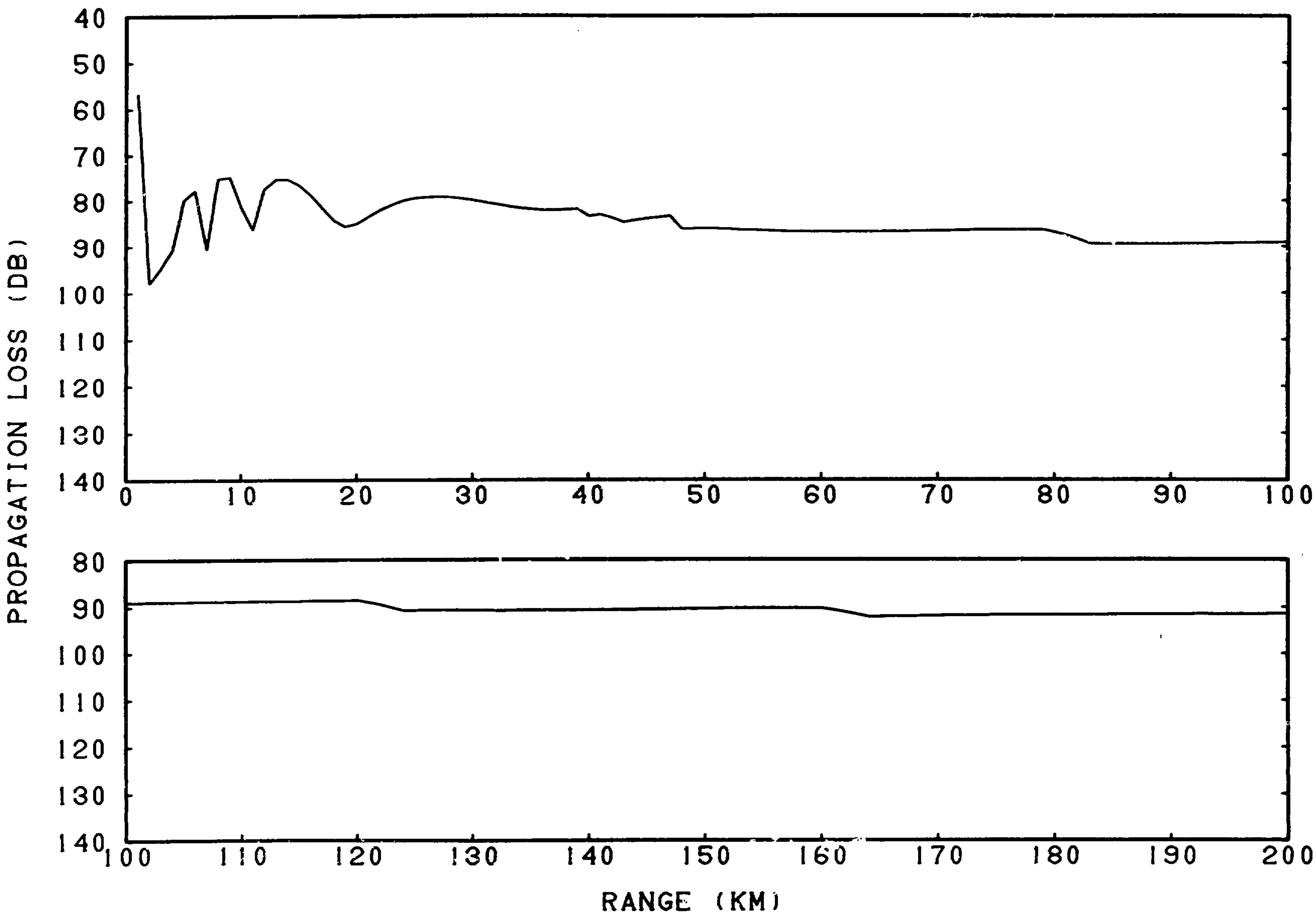
CONFIDENTIAL

(C) Figure IIB-48. FACT (Incoherent) Case VI, Bottom Loss = FNOC Type 3, Frequency = 100 Hertz



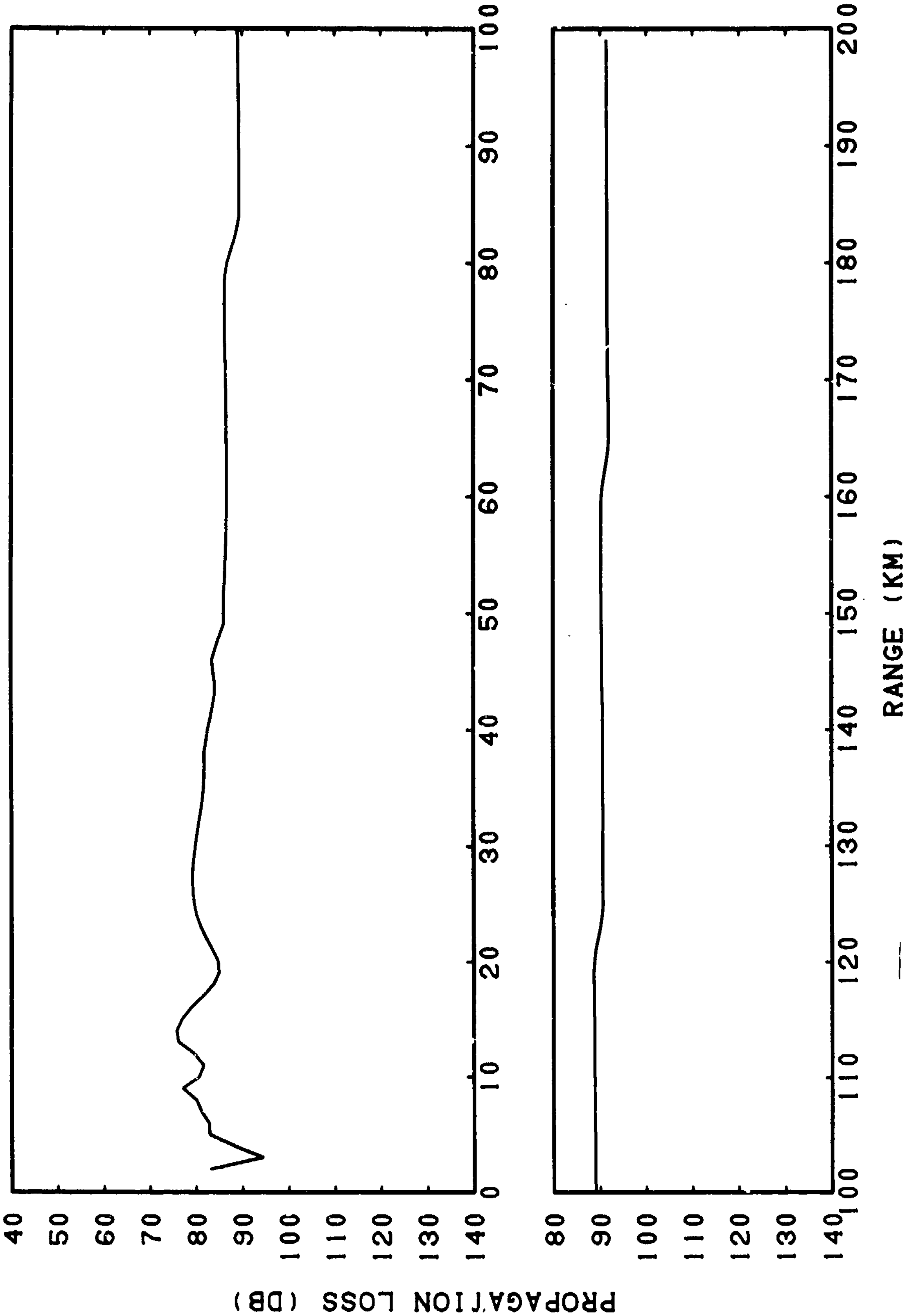
CONFIDENTIAL

(C) Figure IIB-49. FACT (Incoherent) Case VI, Bottom Loss = FNOC Type 3, Frequency = 100 Hertz, Subtracted from Hays-Murphy Data, Case VI, Source Depth = 80 Feet, Receiver Depth = 350 Feet, Frequency = 100 Hertz



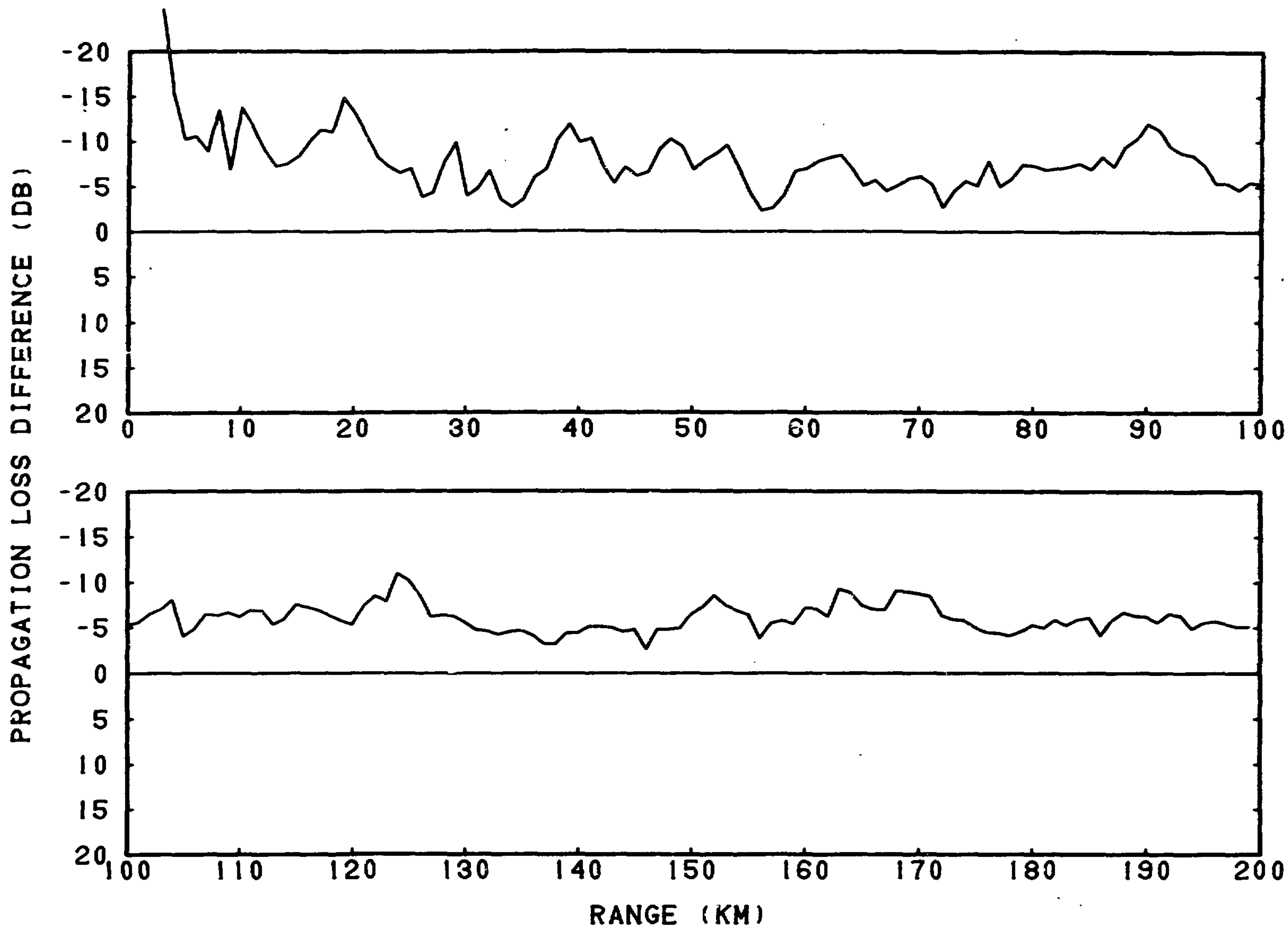
CONFIDENTIAL

(C) Figure IIB-50. FACT (Coherent) Case I, Bottom Loss = MGS Type 2, Frequency = 35 Hertz



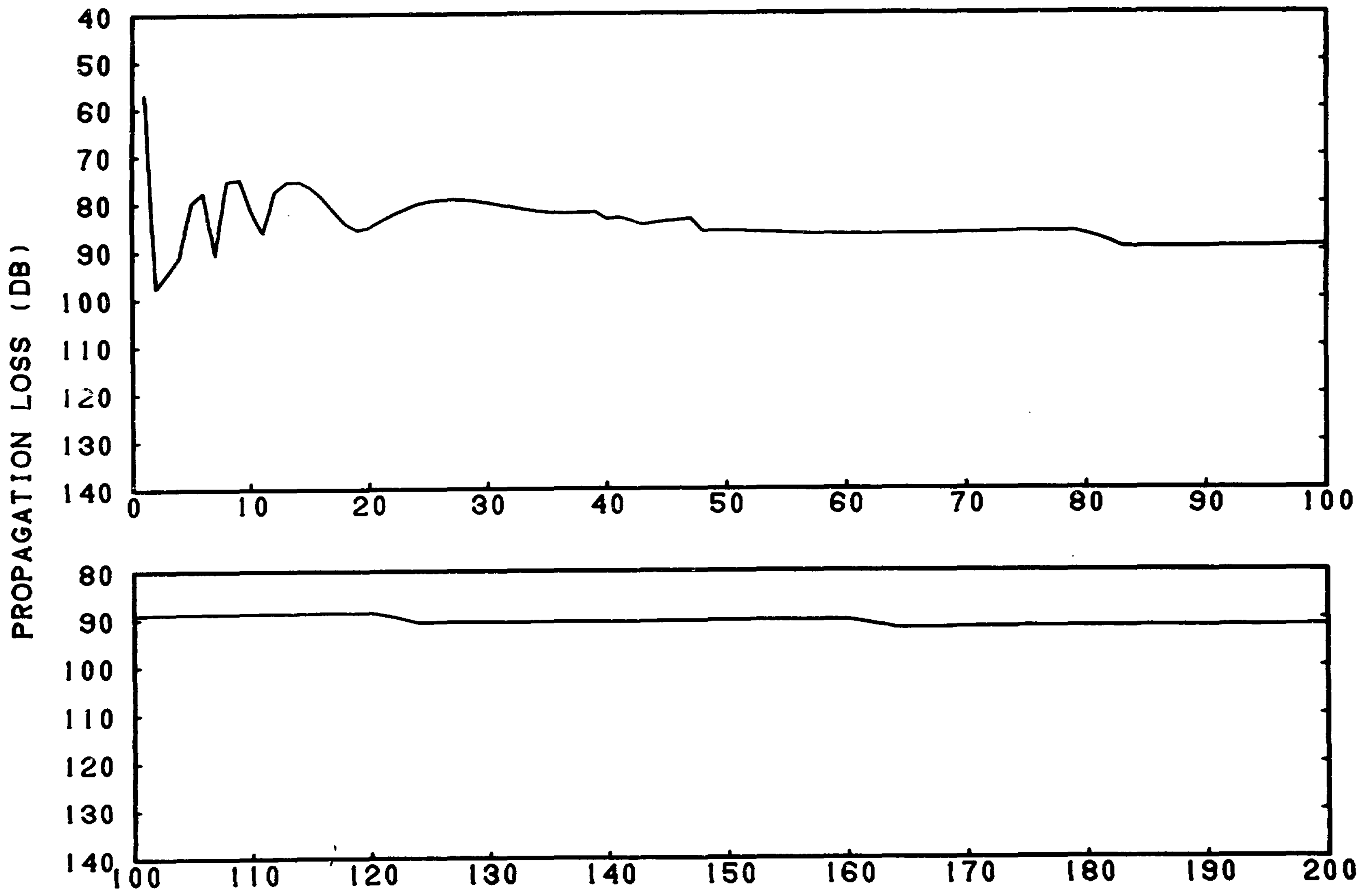
CONFIDENTIAL

(C) Figure IIB-51. FACT (Coherent) Case 1, Bottom Loss = MGS Type 2, Frequency = 35 Hertz, Sliding Averages of 3 Points (2.00 Kilometer)



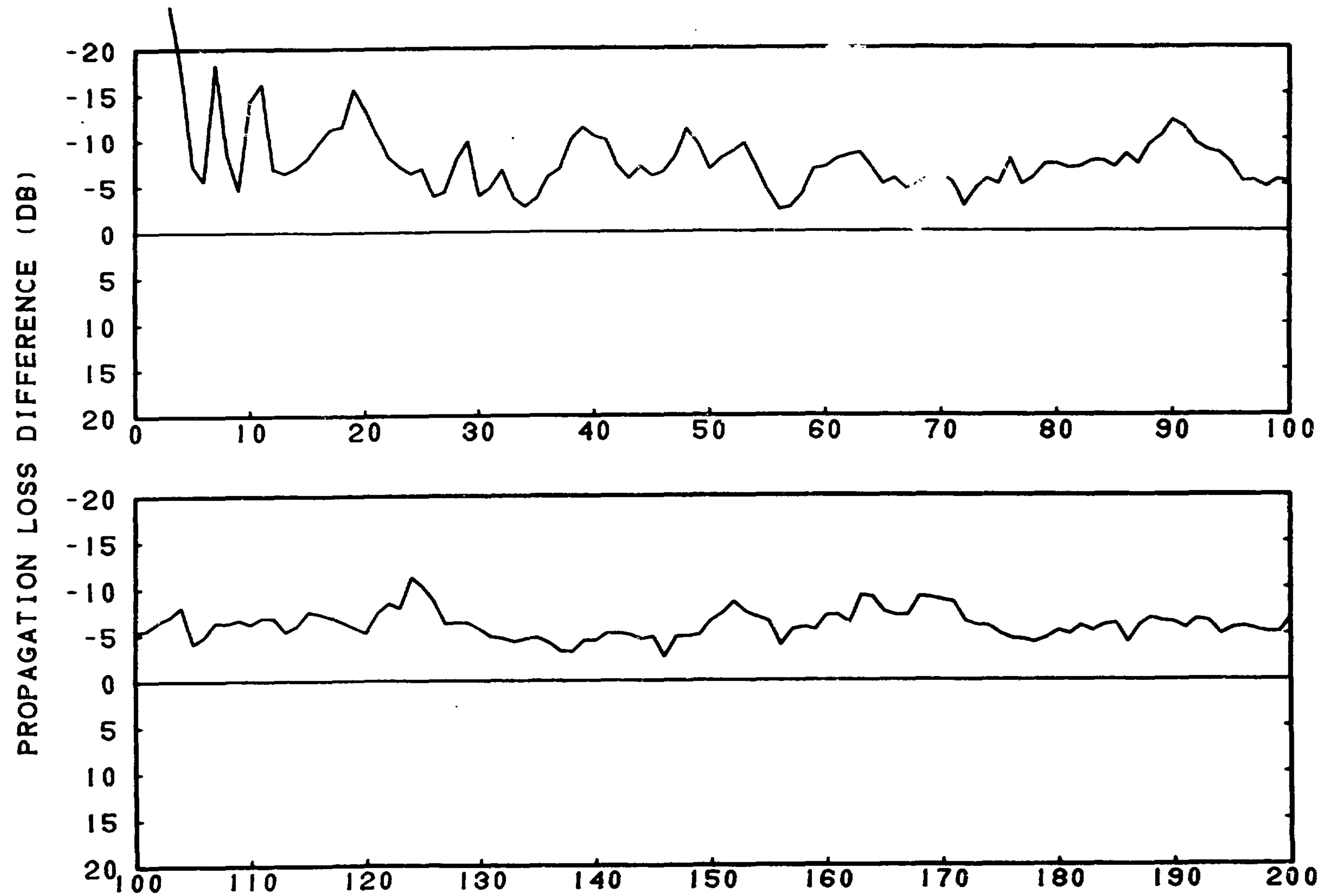
CONFIDENTIAL

(C) Figure IIB-52. Smoothed FACT (Coherent) Case I, Bottom Loss = MGS Type 2, Frequency = 35 Hertz, Subtracted from Hays-Murphy Data, Case I, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 35 Hertz



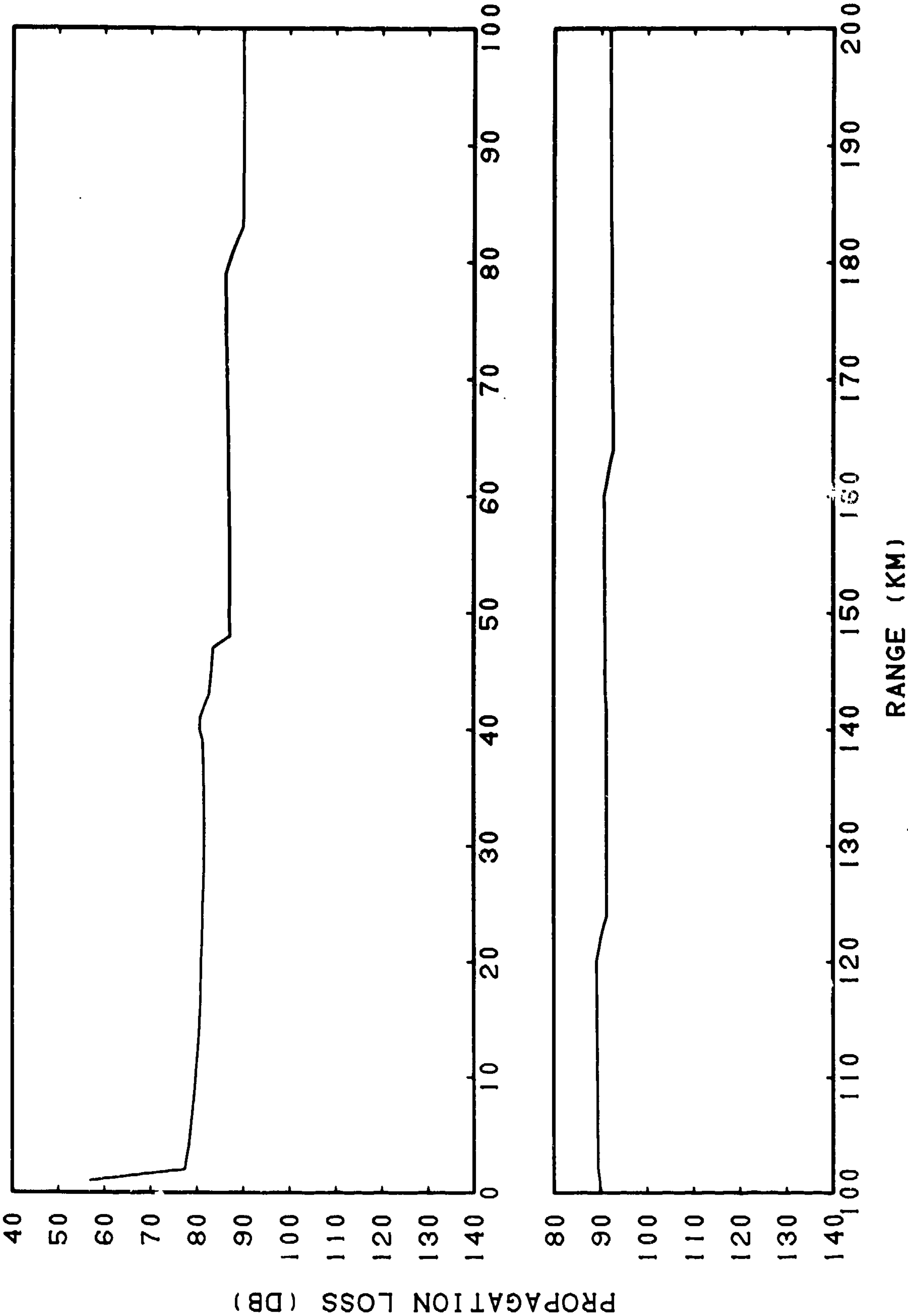
CONFIDENTIAL

(C) Figure IIB-53. FACT (Semi-coherent) Case I, Bottom Loss = MGS Type 2, Frequency = 35 Hertz



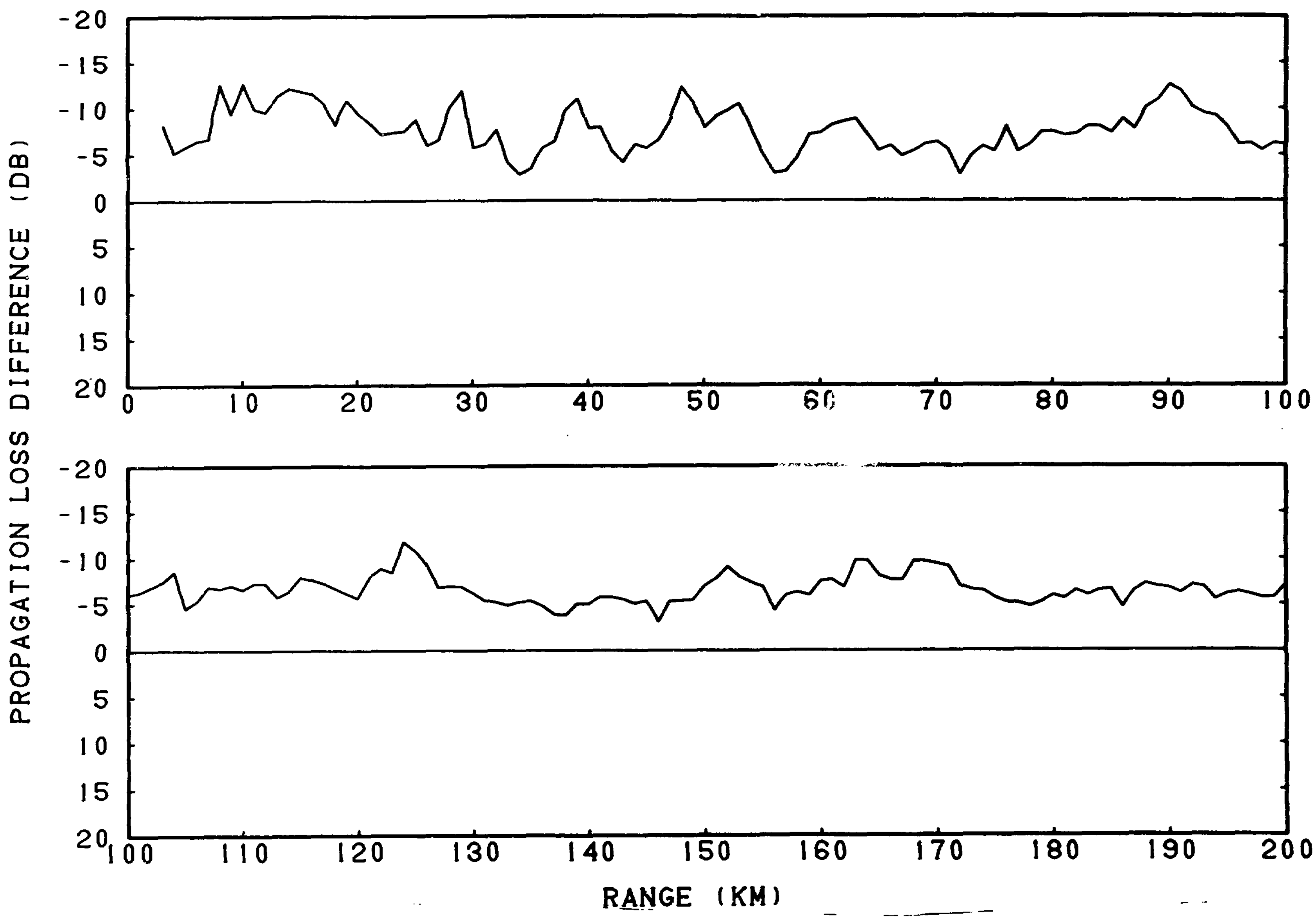
CONFIDENTIAL

(C) Figure IIB-54. FACT (Semi-coherent) Case I, Bottom Loss= MGS Type 2, Frequency = 35 Hertz, Subtracted from Hays-Murphy Data, Case I, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 35 Hertz



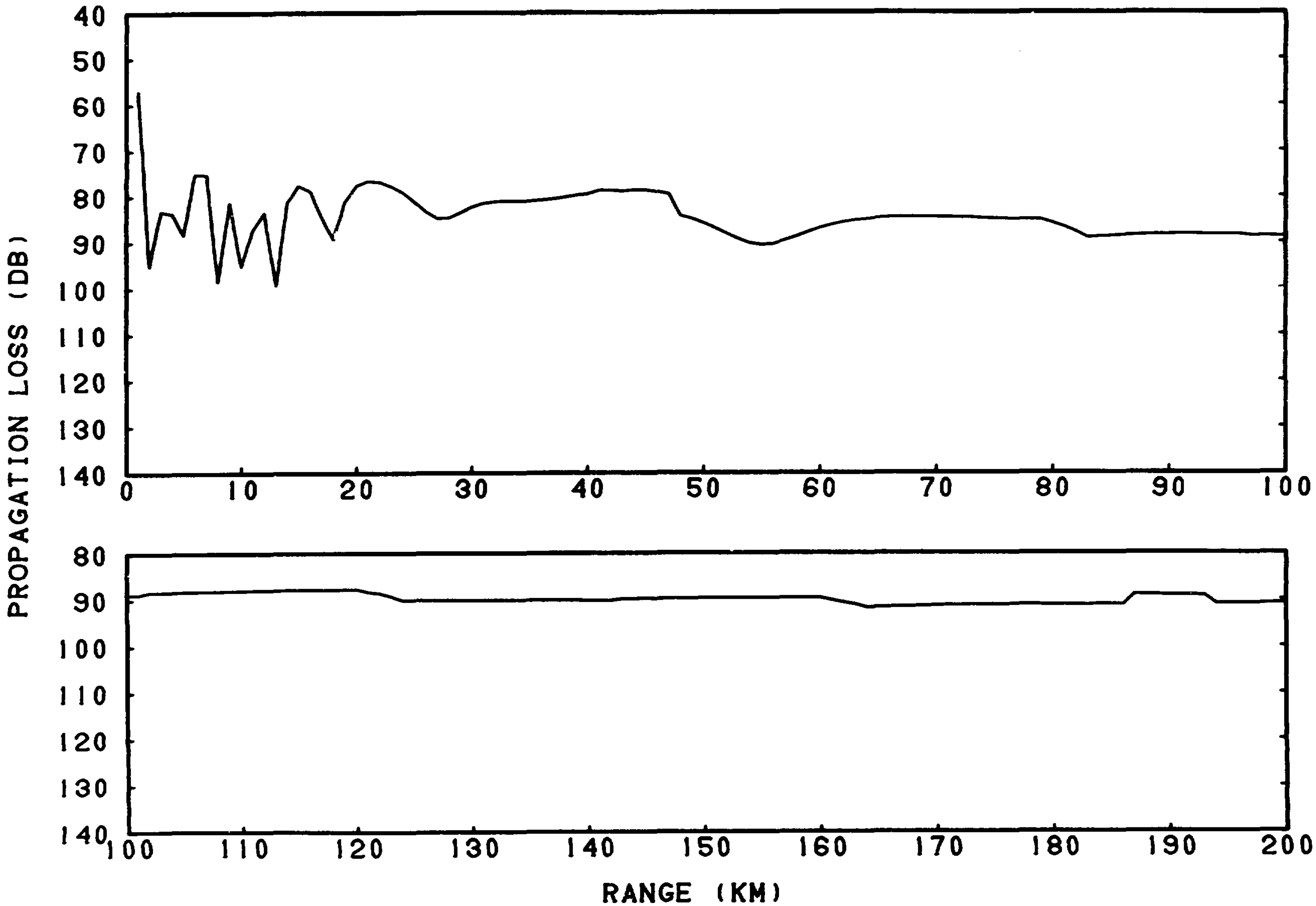
CONFIDENTIAL

(C) Figure IIB-55. FACT (Incoherent) Case I, Bottom Loss = MGS Type 2, Frequency = 35 Hertz



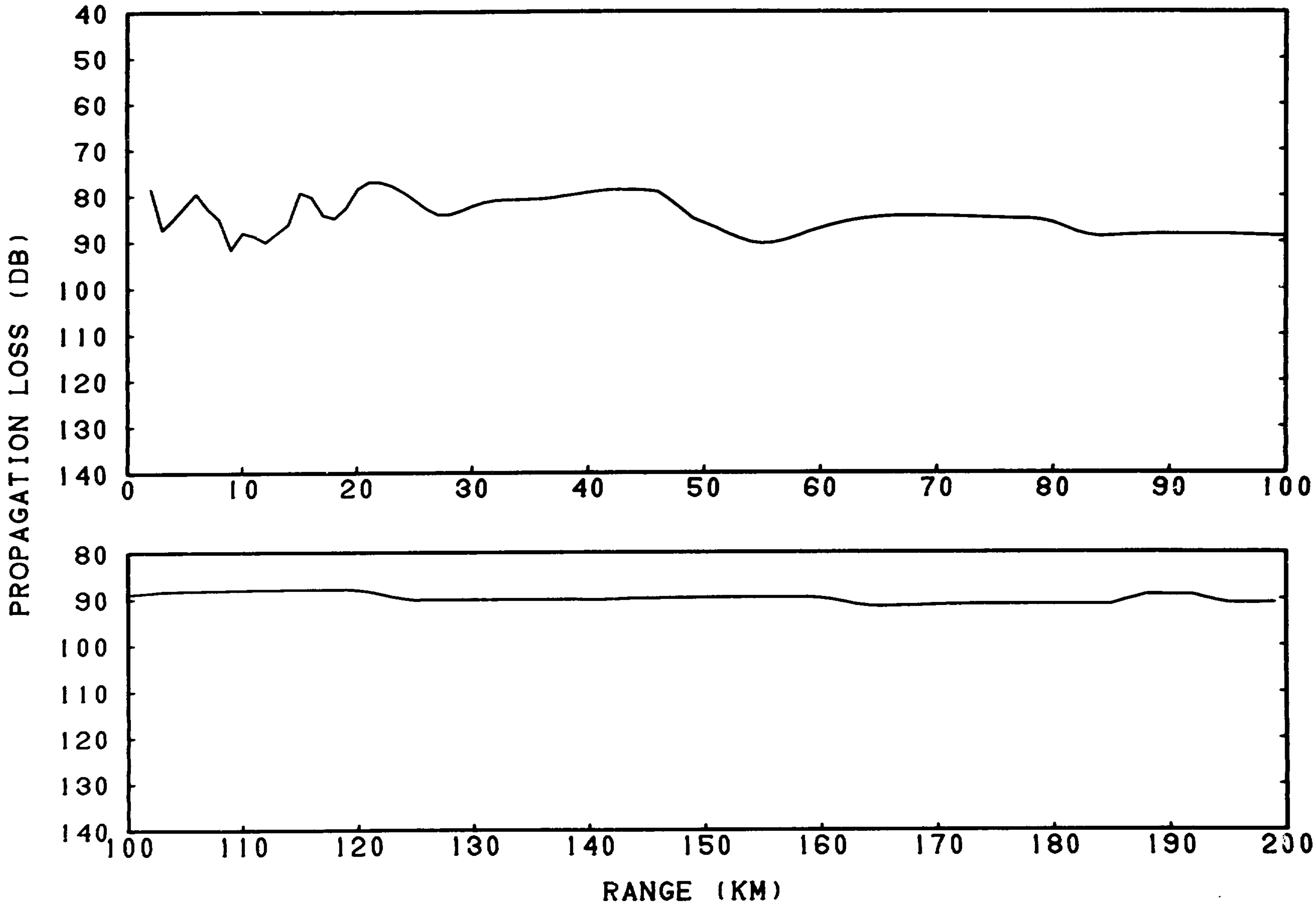
CONFIDENTIAL

(C) Figure IIB-56. FACT (Incoherent) Case I, Bottom Loss = MGS Type 2, Frequency = 35 Hertz, Subtracted from Hays-Murphy Data, Case I, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 35 Hertz

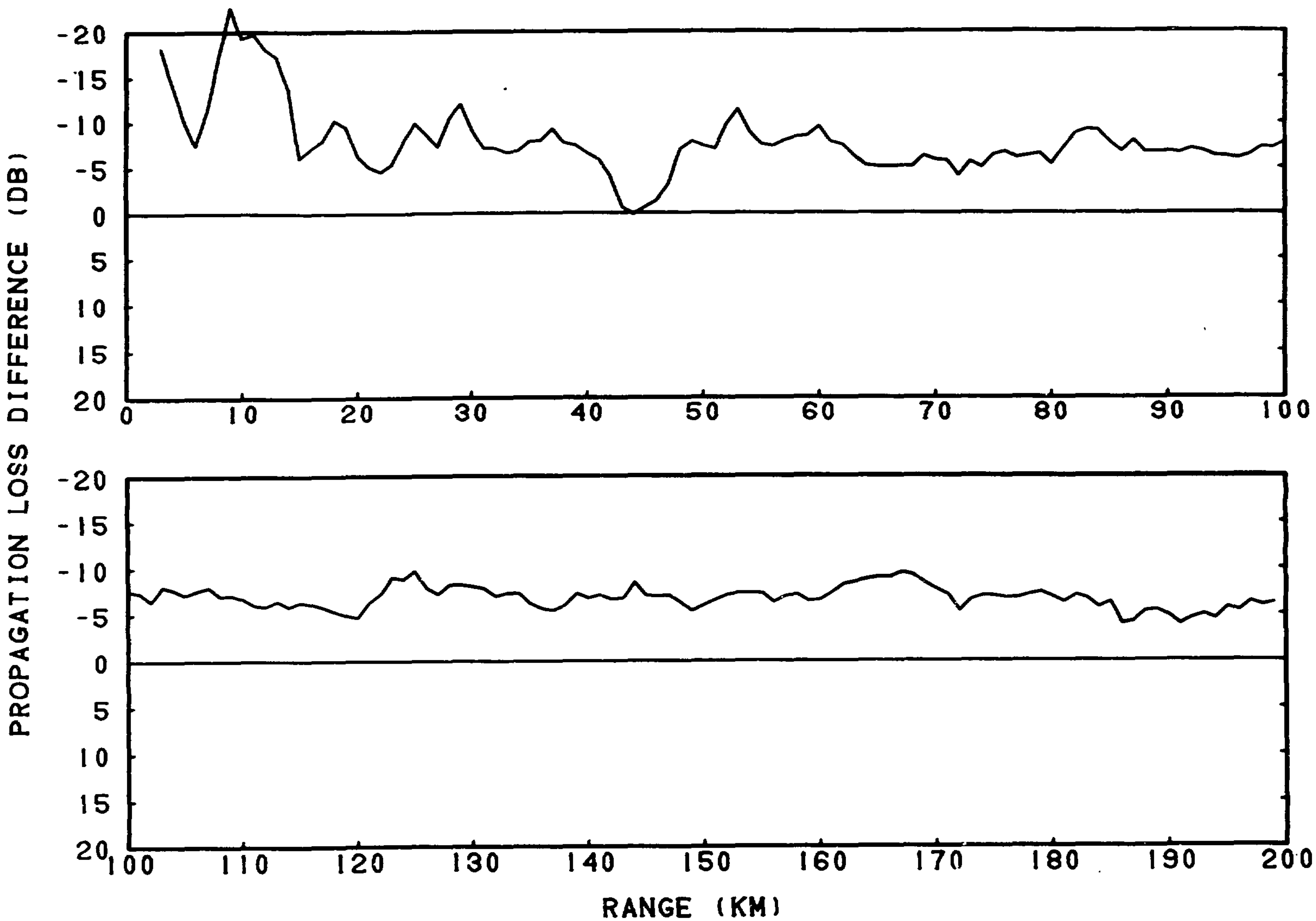


CONFIDENTIAL

(C) Figure IIB-57. FACT (Coherent) Case II, Bottom Loss = MGS Type 2, Frequency = 67.5 Hertz

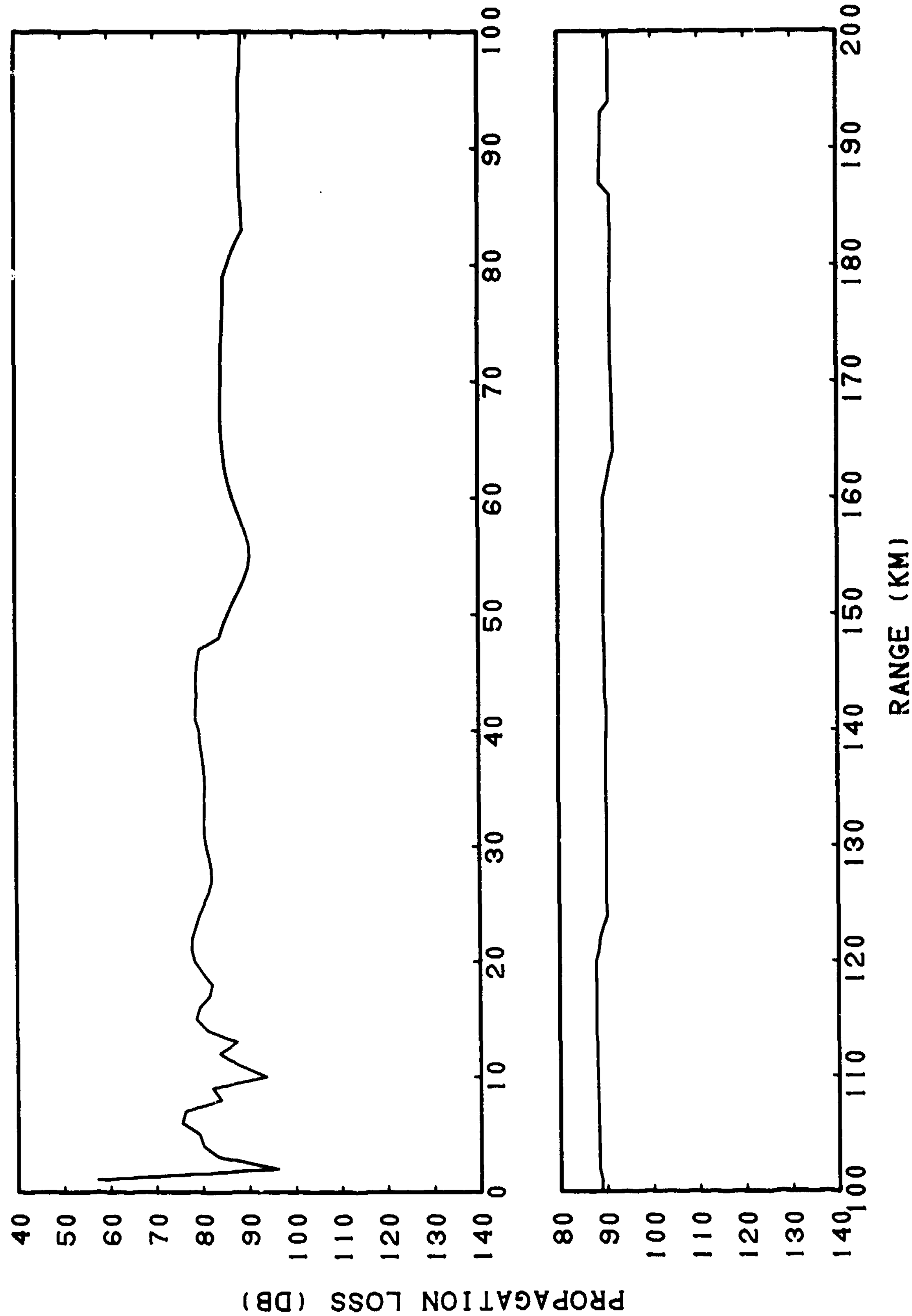


(C) Figure IIB-58. FACT (Coherent) Case II, Bottom Loss = MGS Type 2, Frequency = 67.5 Hertz, Sliding Averages of 3 Points (2.00 Kilometer)



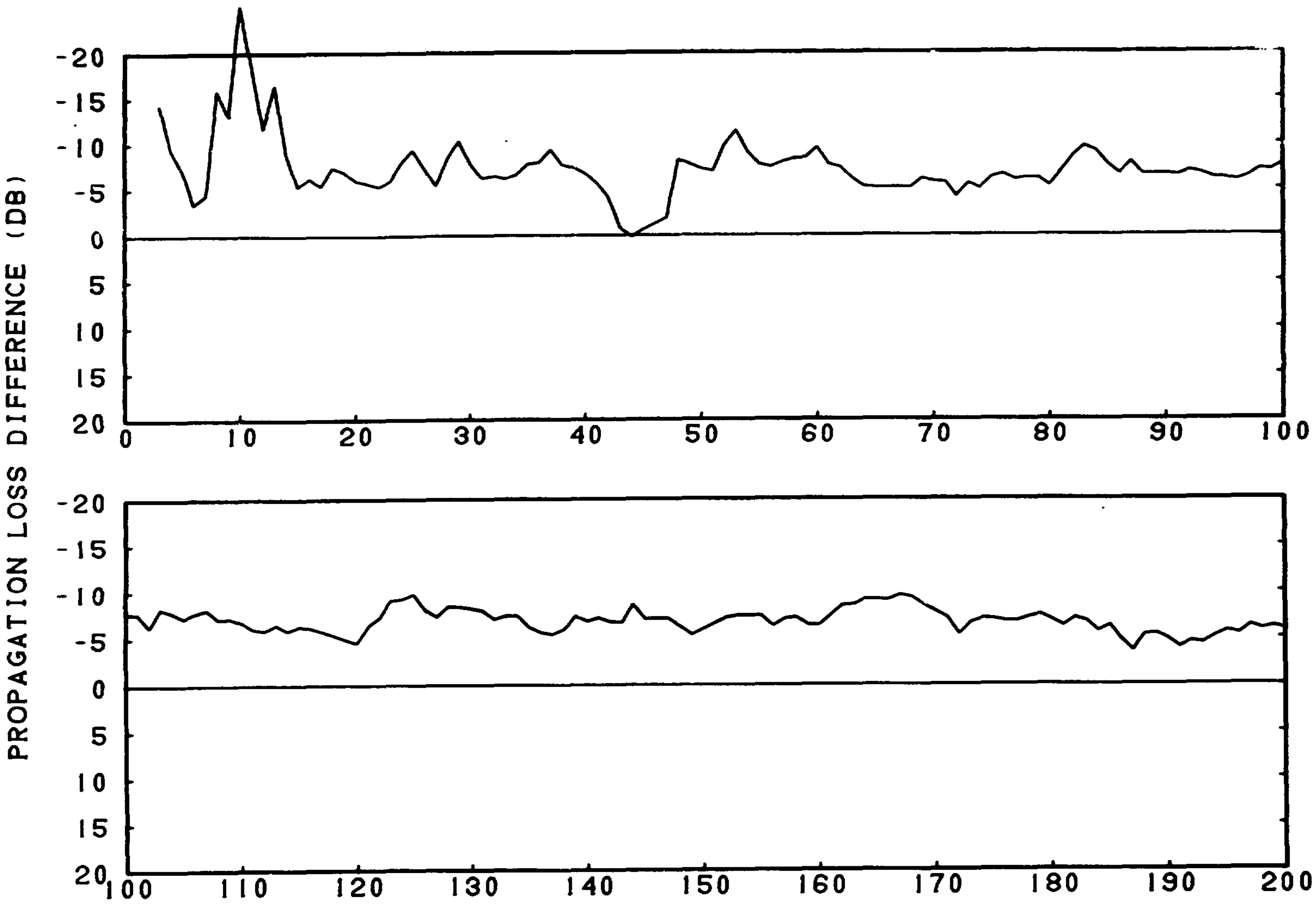
CONFIDENTIAL

(C) Figure IIB-59. Smoothed FACT (Coherent) Case II, Bottom Loss = MGS Type 2, Frequency = 67.5 Hertz, Subtracted from Hays-Murphy Data, Case II, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 67.5 Hertz



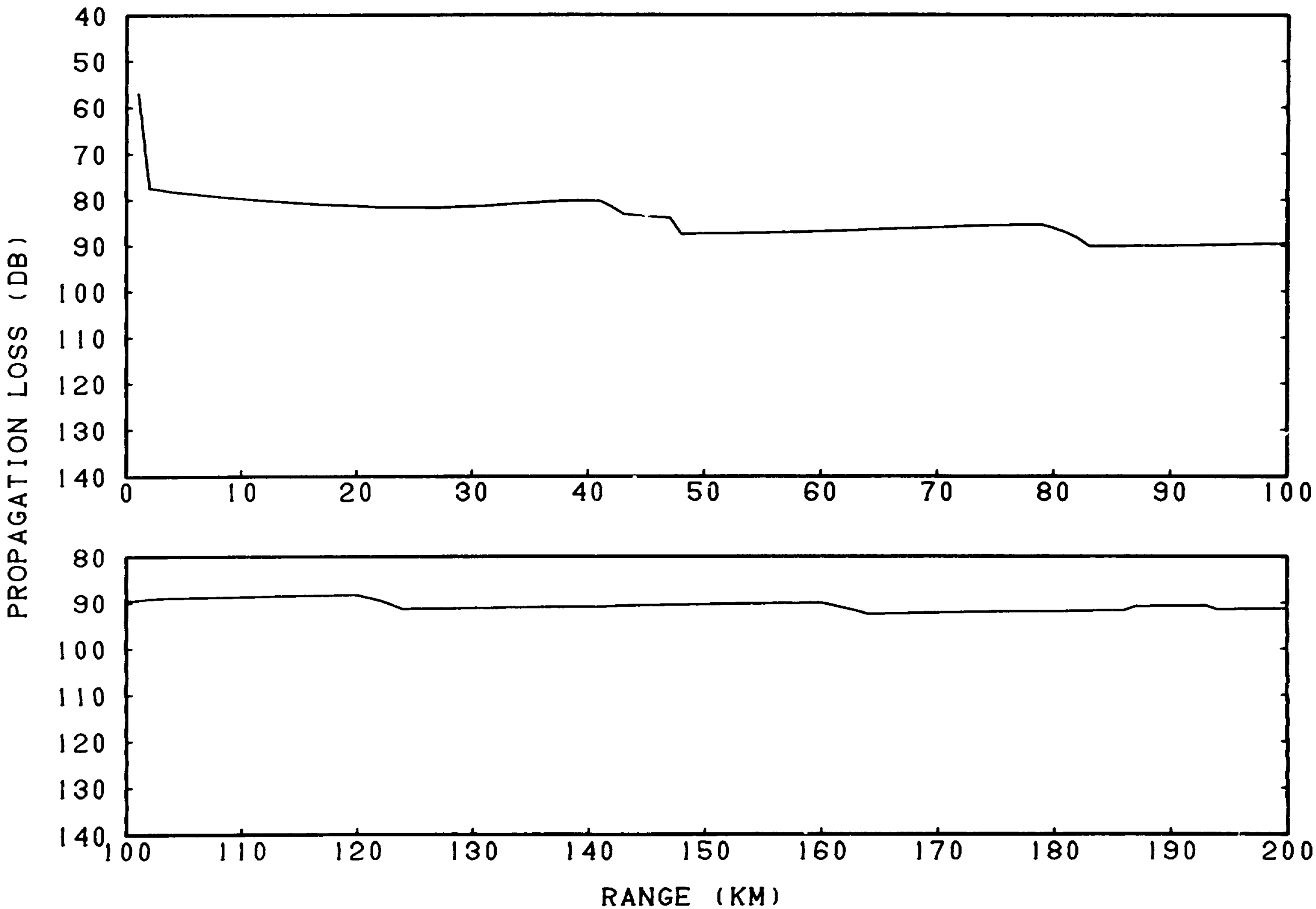
CONFIDENTIAL

(C) Figure IIB-60. FACT (Semi-coherent) Case II, Bottom Loss = MGS Type 2, Frequency = 67.5 Hertz



CONFIDENTIAL

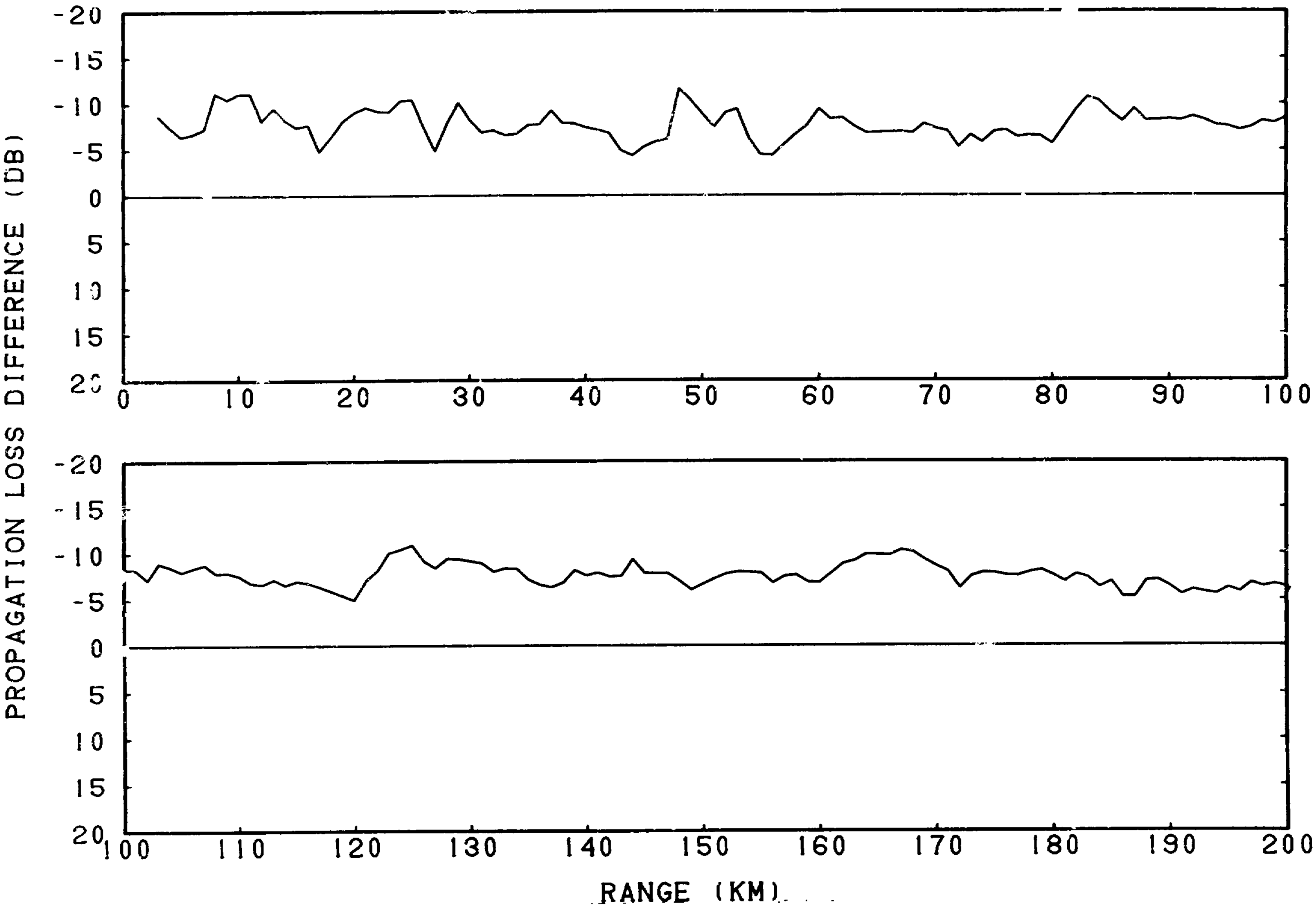
(C) Figure IIB-61. FACT (Semi-coherent) Case II, Bottom Loss = MGS Type 2, Frequency = 67.5 Hertz, Subtracted from Hays-Murphy Data, Case II, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 67.5 Hertz



CONFIDENTIAL

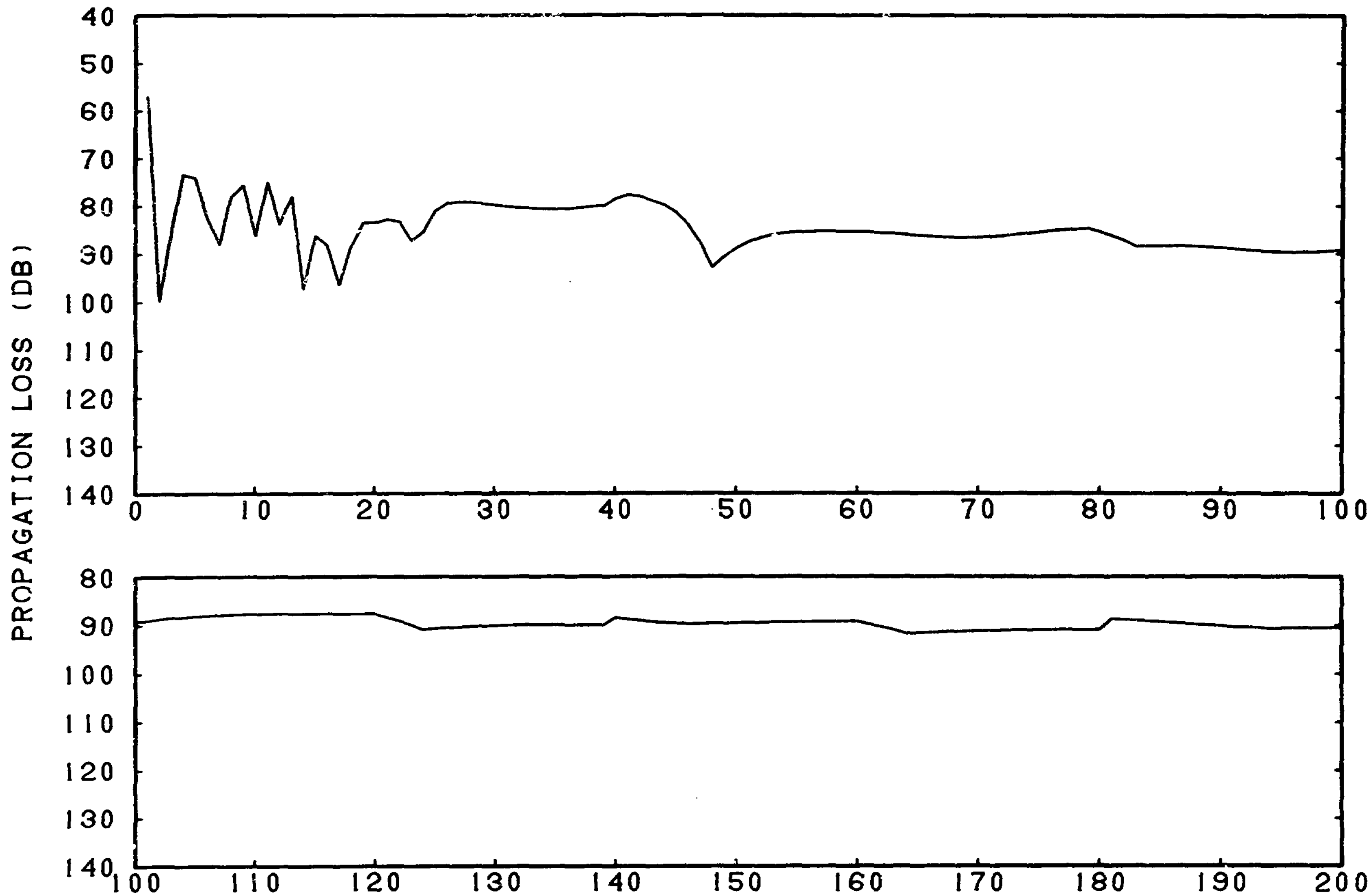
(C) Figure IIB-62. FACT (Incoherent) Case II, Bottom Loss = MGS Type 2, Frequency = 67.5 Hertz

CONFIDENTIAL



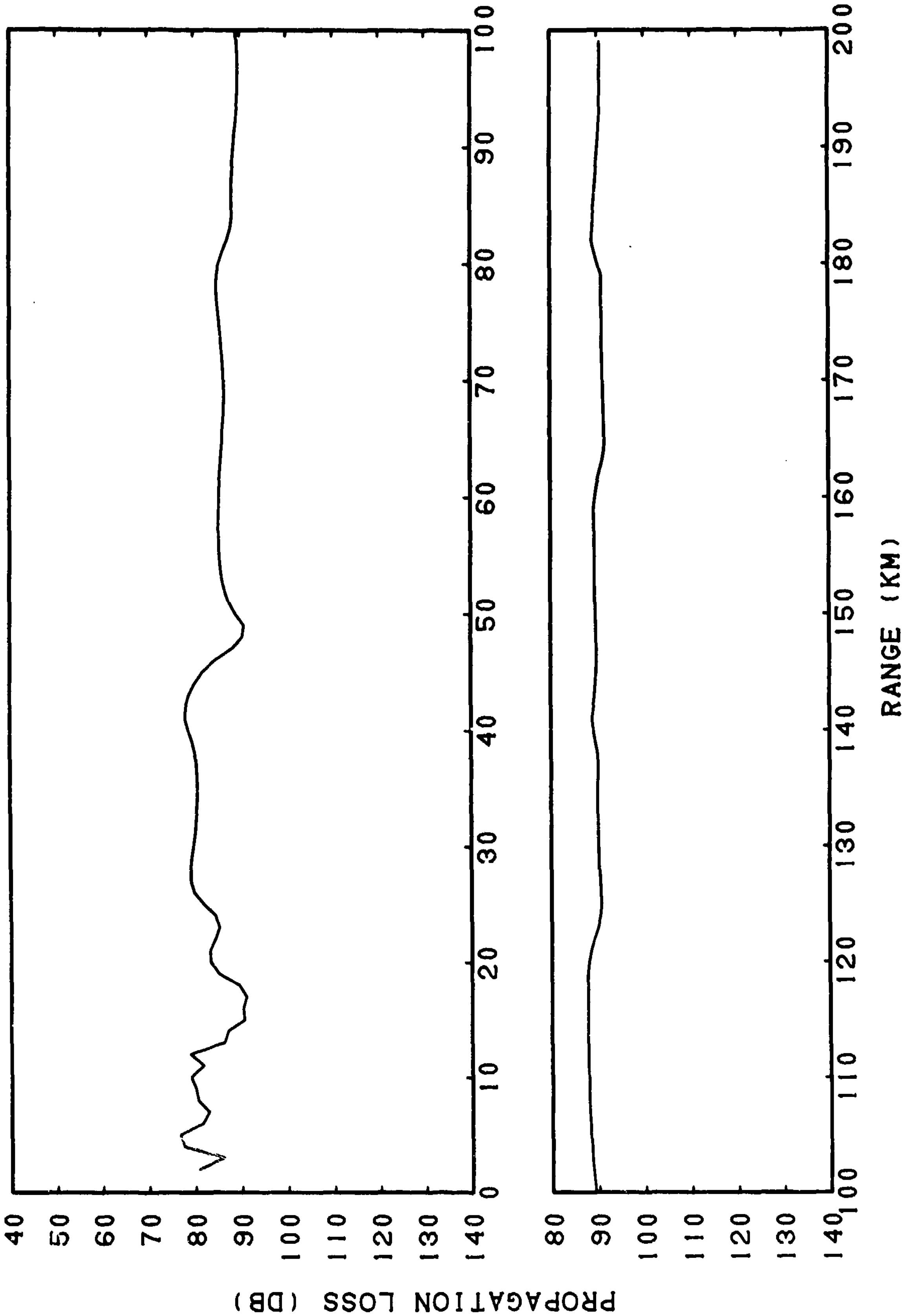
CONFIDENTIAL

(C) Figure IIB-63. FACT (Incoherent) Case II, Bottom Loss = MGS Type 2, Frequency = 67.5 Hertz, Subtracted from Hays-Murphy Data, Case II, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 67.5 Hertz



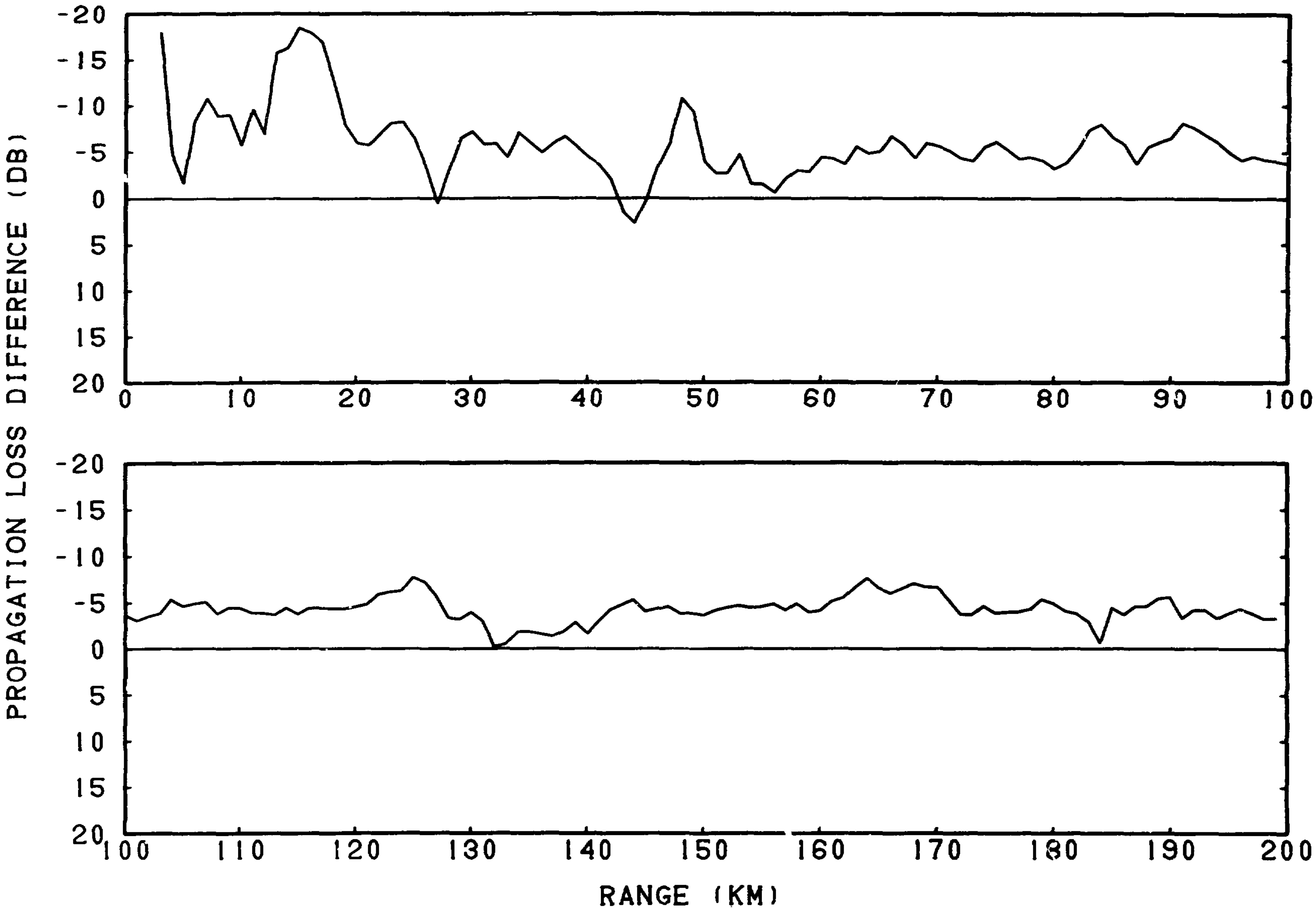
CONFIDENTIAL

(C) Figure IIB-64. FACT (Coherent) Case III, Bottom Loss = MGS Type 2, Frequency = 100 Hertz



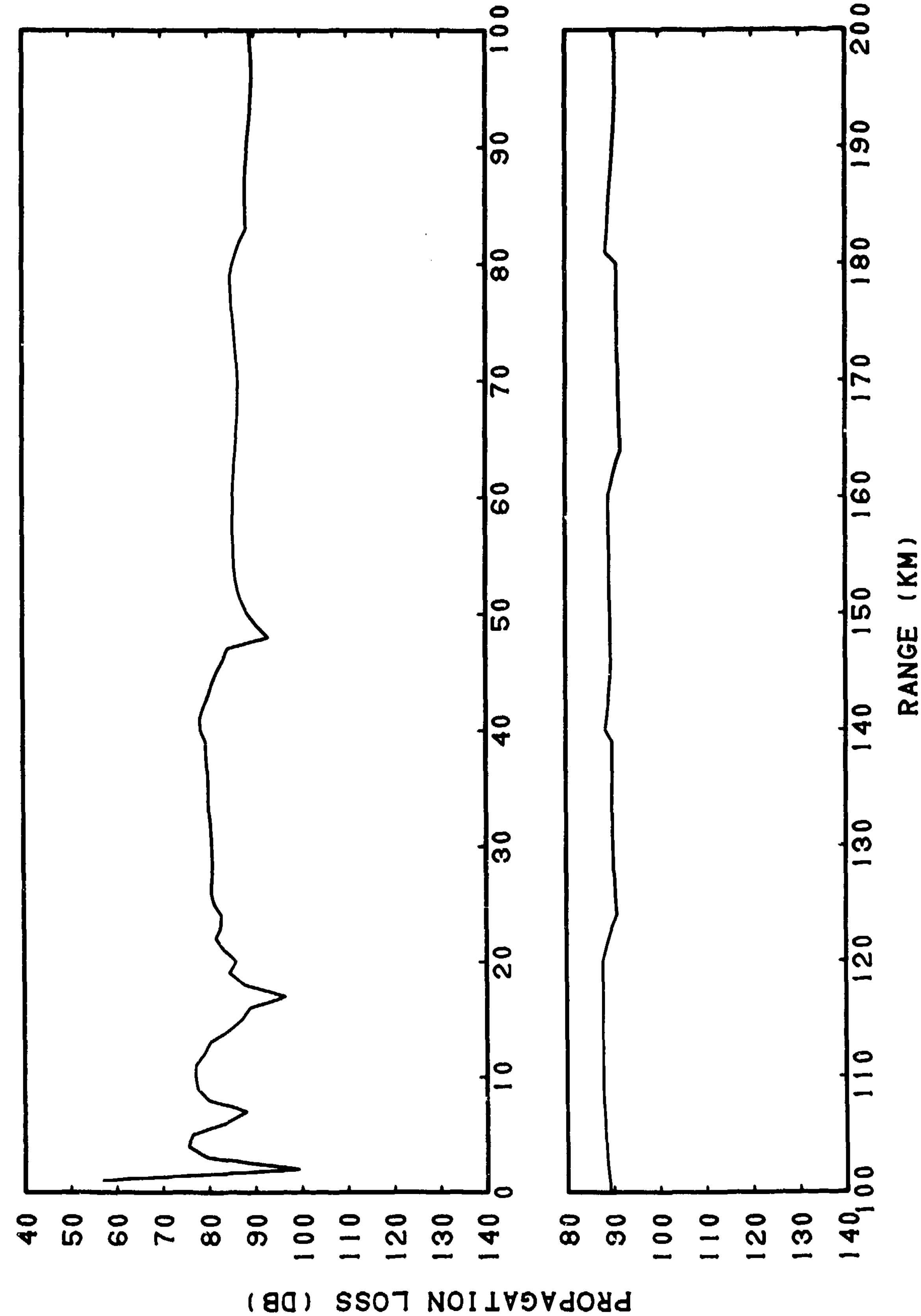
CONFIDENTIAL

(C) Figure IIB-65. FACT (Coherent) CASE III, Bottom Loss = MGS Type 2, Frequency = 100 Hertz, Sliding Averages of 3 Points (2.00 Kilometer)



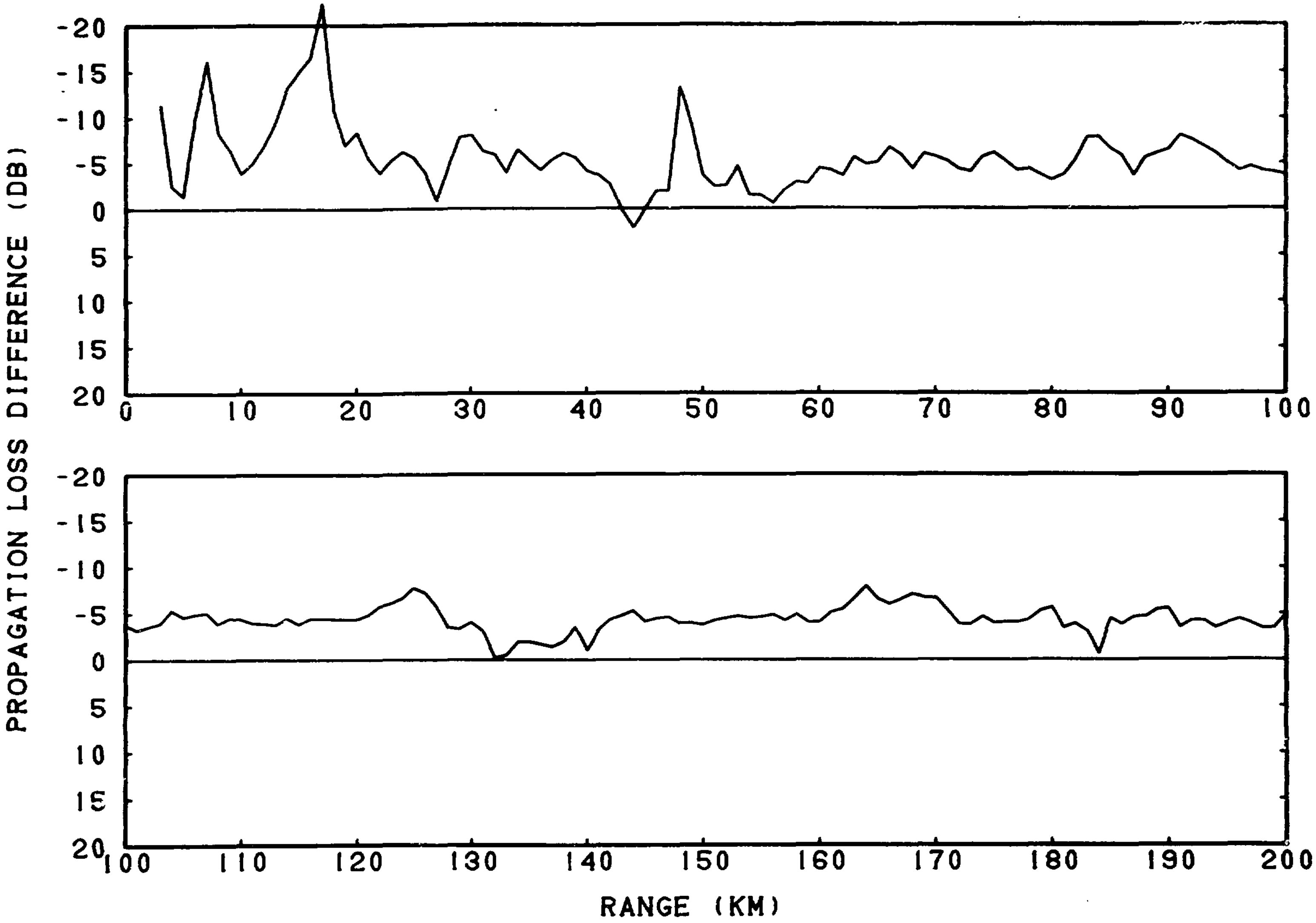
CONFIDENTIAL

(C) Figure IIB-66. Smoothed FACT (Coherent) Case III, Bottom Loss = MGS Type 2, Frequency = 100 Hertz, Subtracted from Hays-Murphy Data, Case III, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 100 Hertz



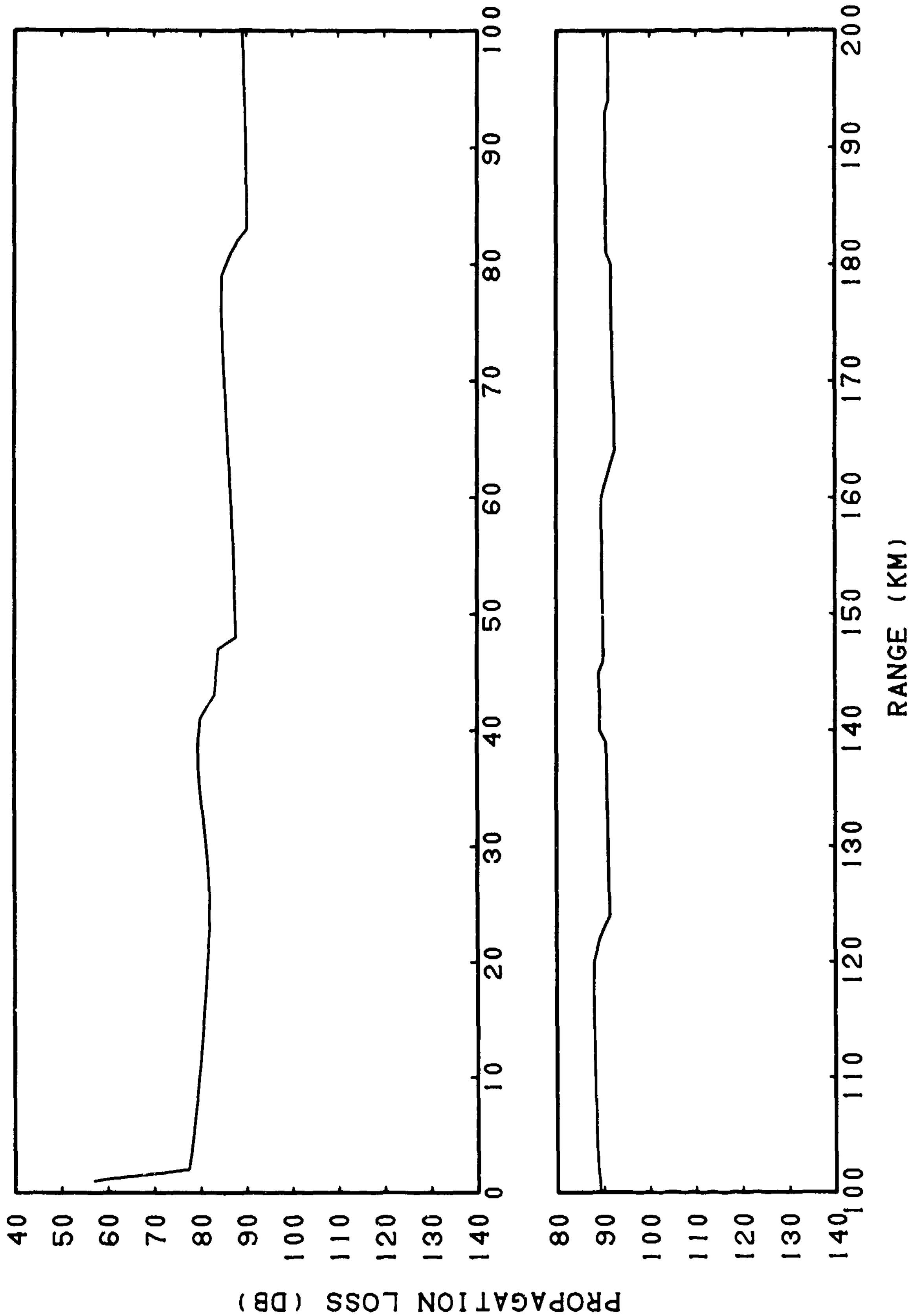
CONFIDENTIAL

(C) Figure IIB-67. FACT (Semi-coherent) Case III, Bottom Loss = MGS Type 2, Frequency = 100 Hertz



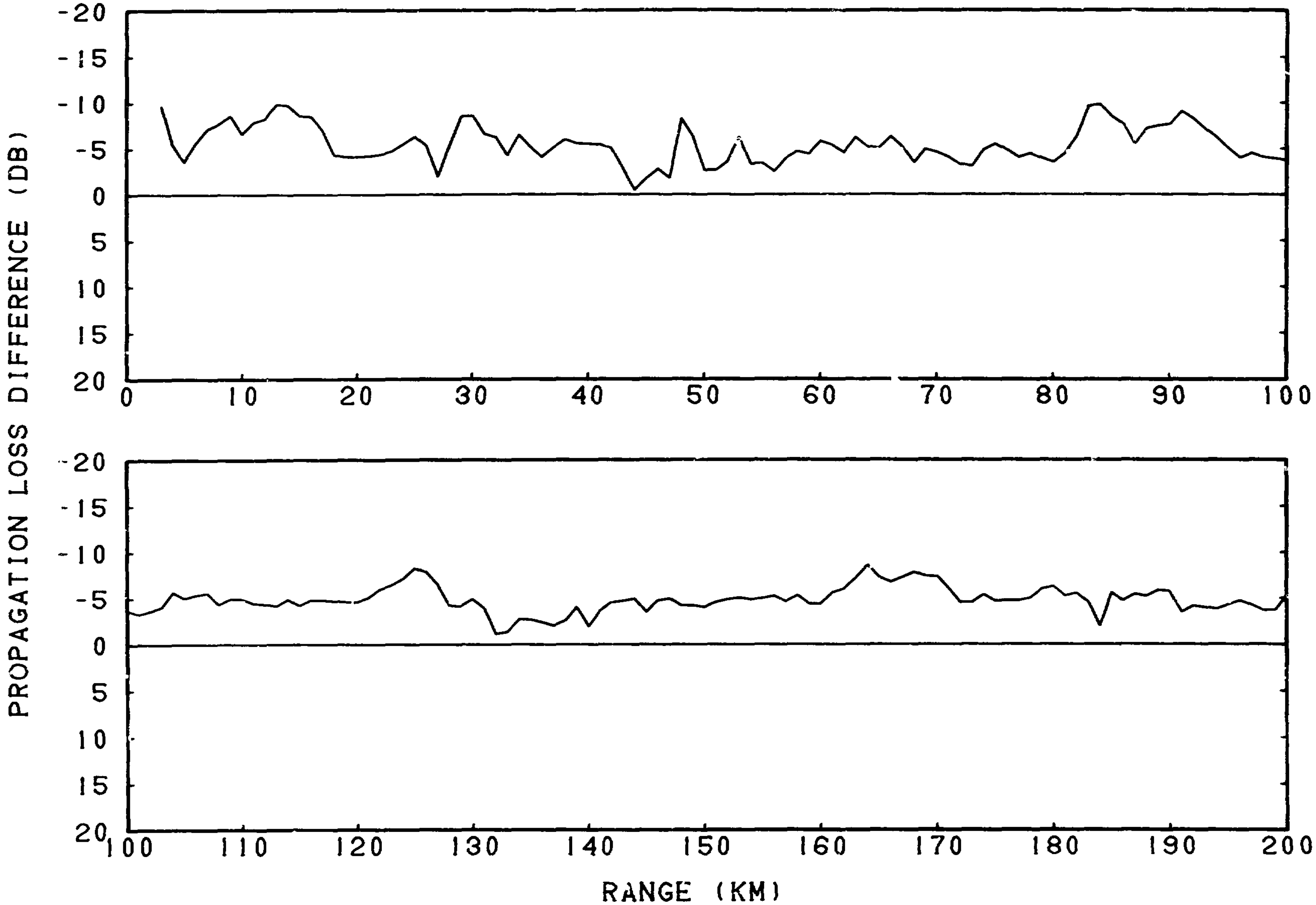
CONFIDENTIAL

(C) Figure IIB-68. FACT (Semi-coherent) Case III. Bottom Loss = MGS Type 2, Frequency = 100 Hertz, Subtracted from Hays-Murphy Data, Case III, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 100 Hertz



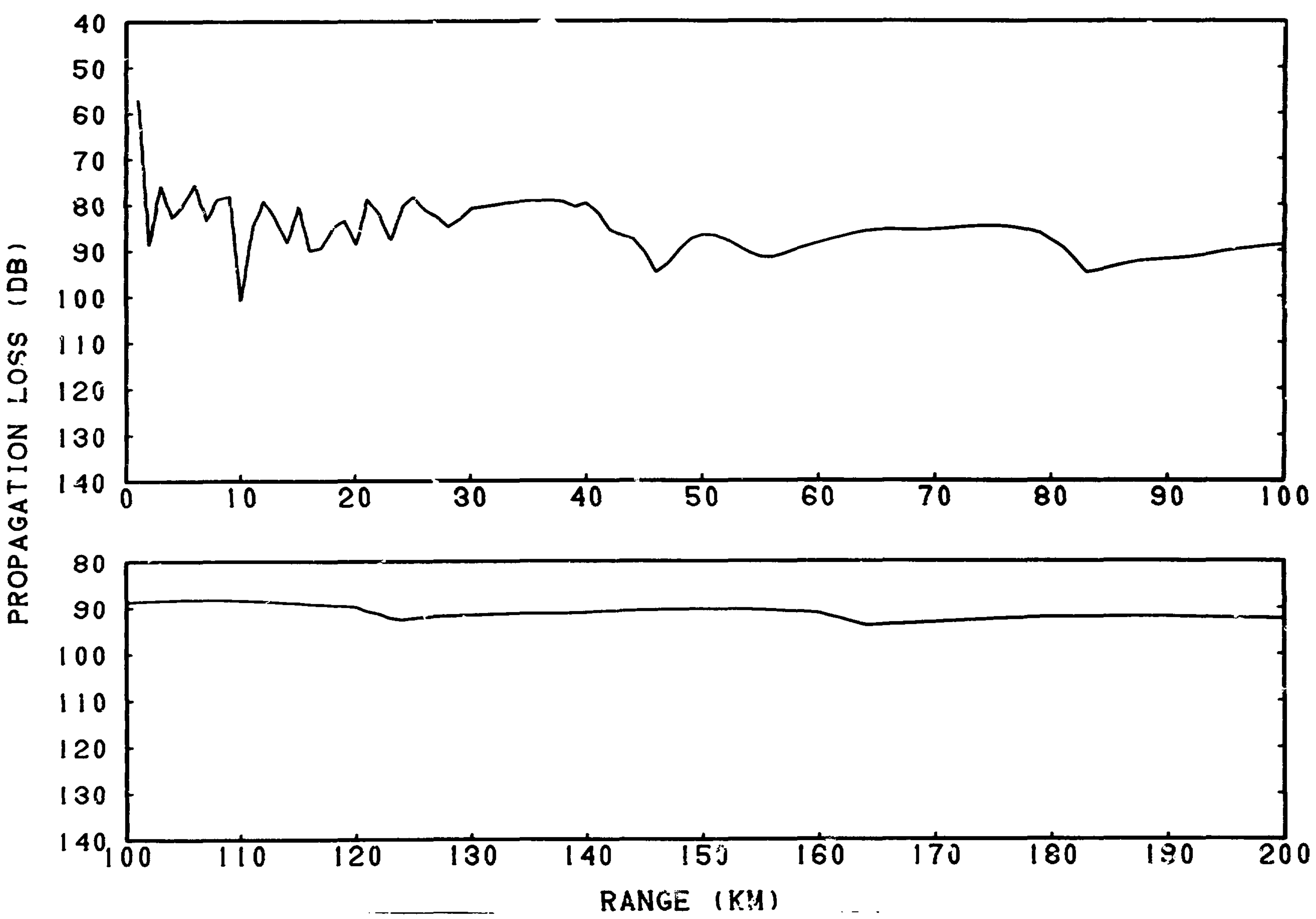
CONFIDENTIAL

(C) Figure IIB-69. FACT (Incoherent) Case III, Bottom Loss = MGS Type 2, Frequency = 100 Hertz



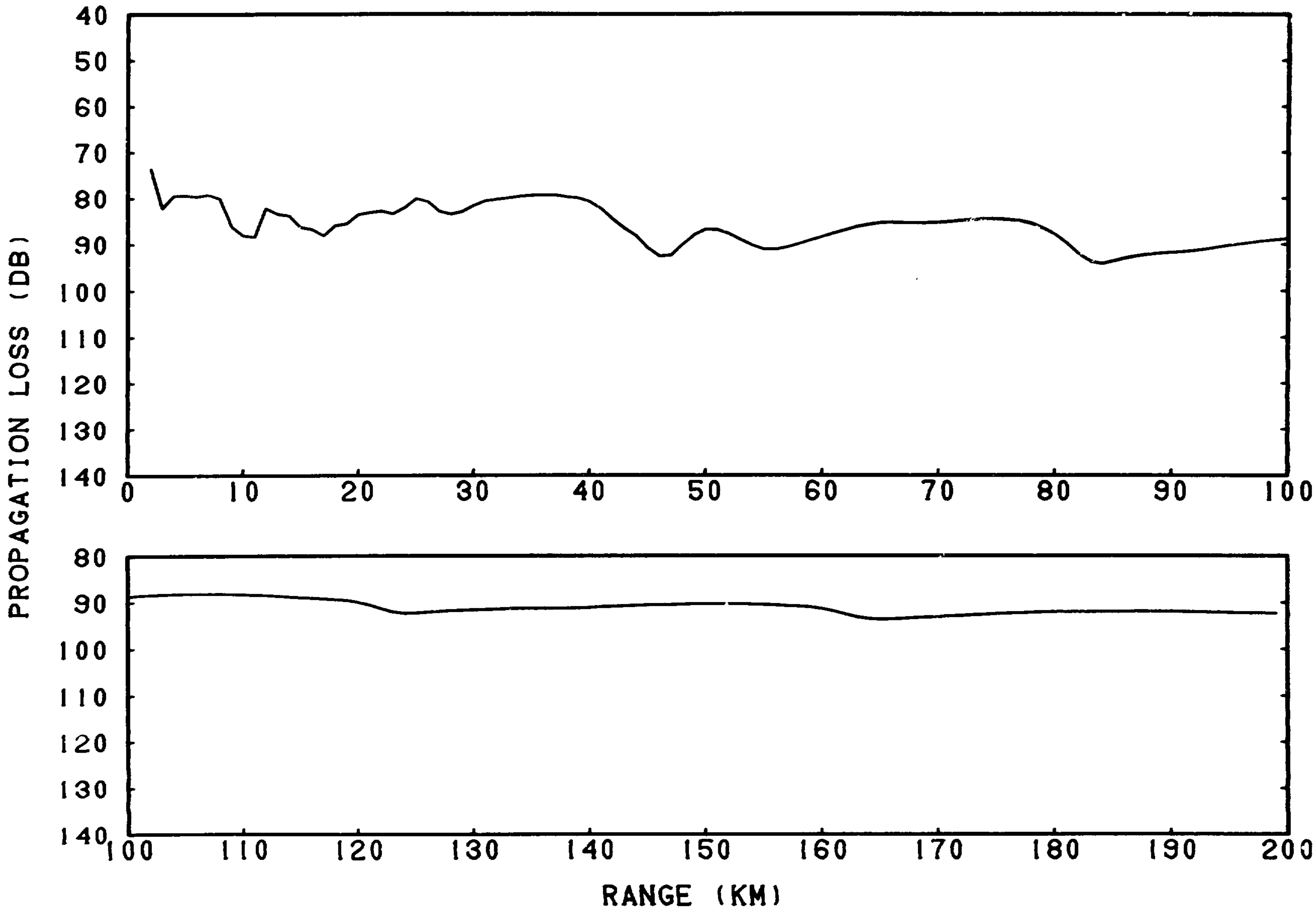
CONFIDENTIAL

(C) Figure IIB-70. FACT (Incoherent) Case III. Bottom Loss = MGS Type 2, Frequency = 100 Hertz, Subtracted from Hays-Murphy Data, Case III, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 100 Hertz



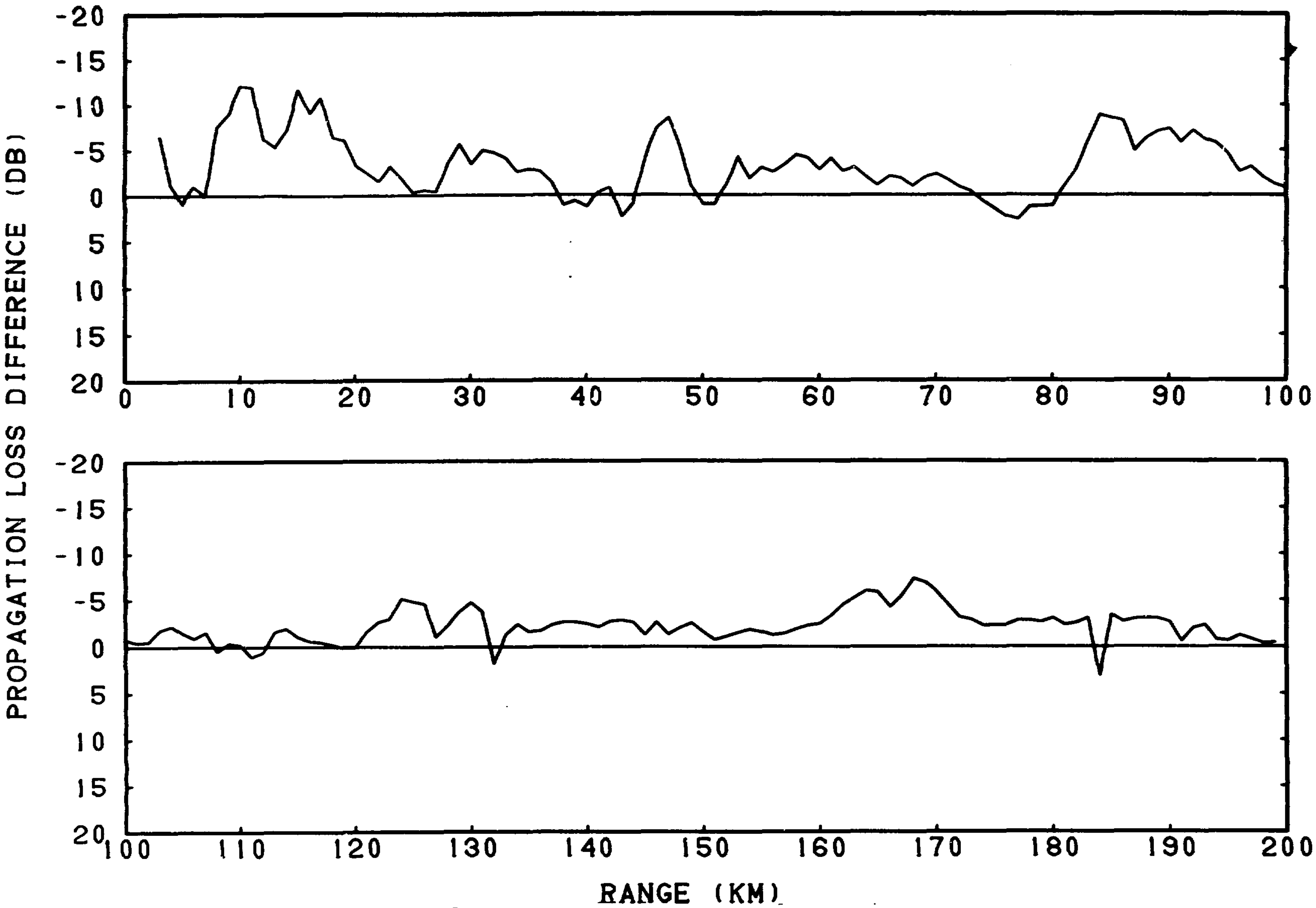
CONFIDENTIAL

(C) Figure IIB-71. FACT (Coherent) Case IV, Bottom Loss = MGS Type 2, Frequency = 200 Hertz



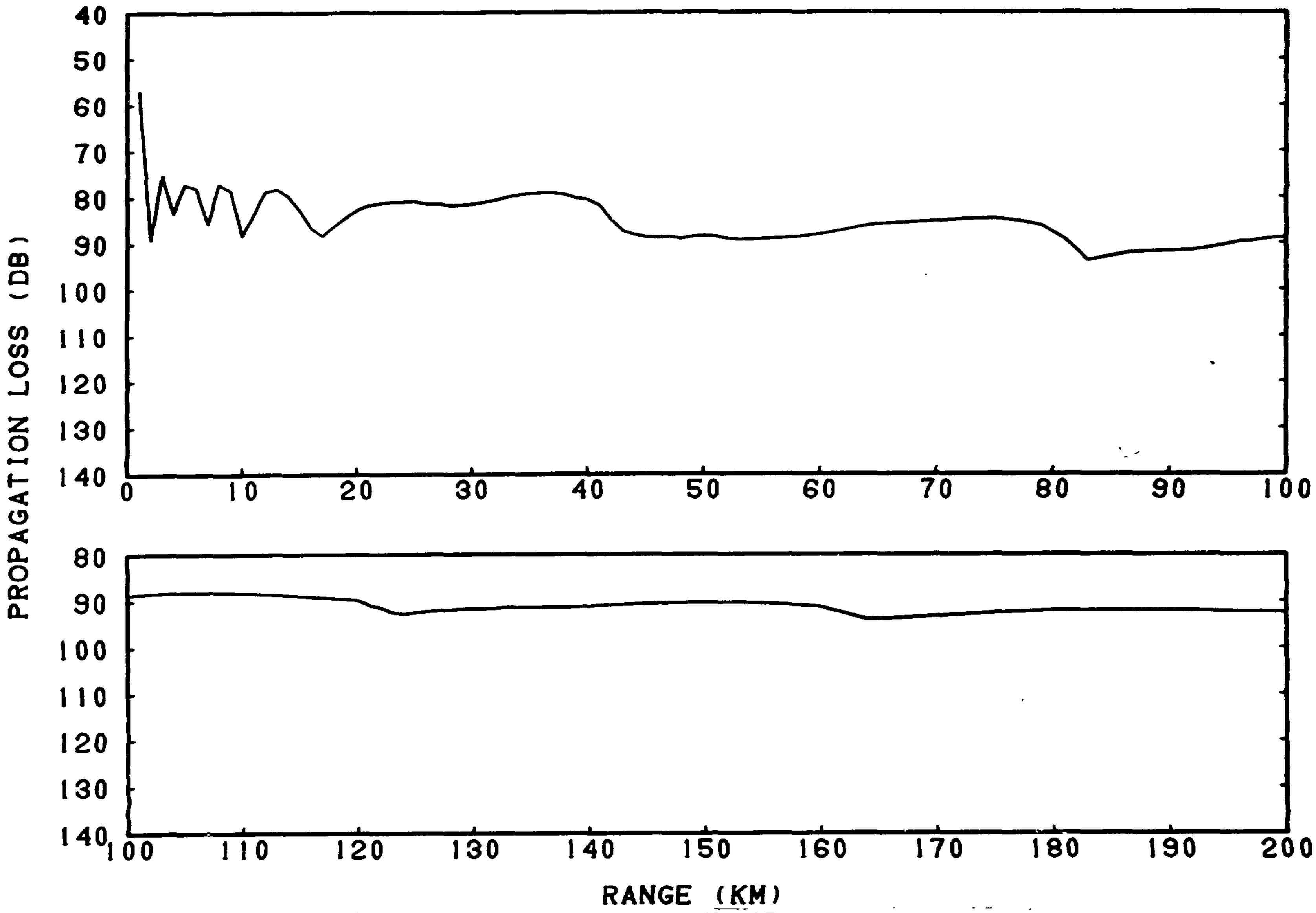
CONFIDENTIAL

(C) Figure IIB-72. FACT (Coherent) Case IV, Bottom Loss = MGS Type 2, Frequency = 200 Hertz, Sliding Averages of 3 Points (2.00 Kilometer)



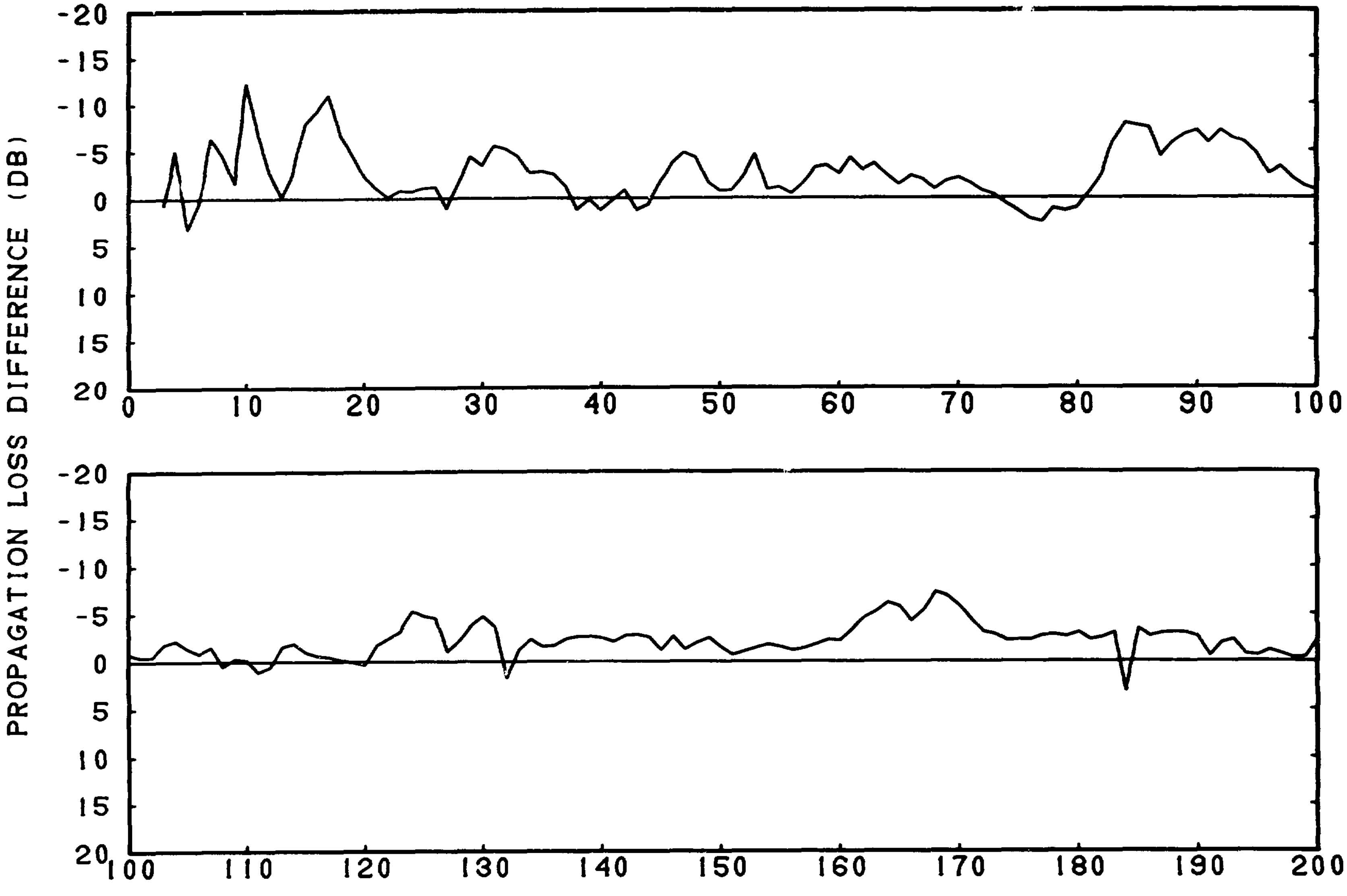
CONFIDENTIAL

(C) Figure IIB-73. Smoothed FACT (Coherent) Case IV, Bottom Loss = MGS Type 2, Frequency = 200 Hertz, Subtracted from Hays-Murphy Data, Case IV, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 200 Hertz



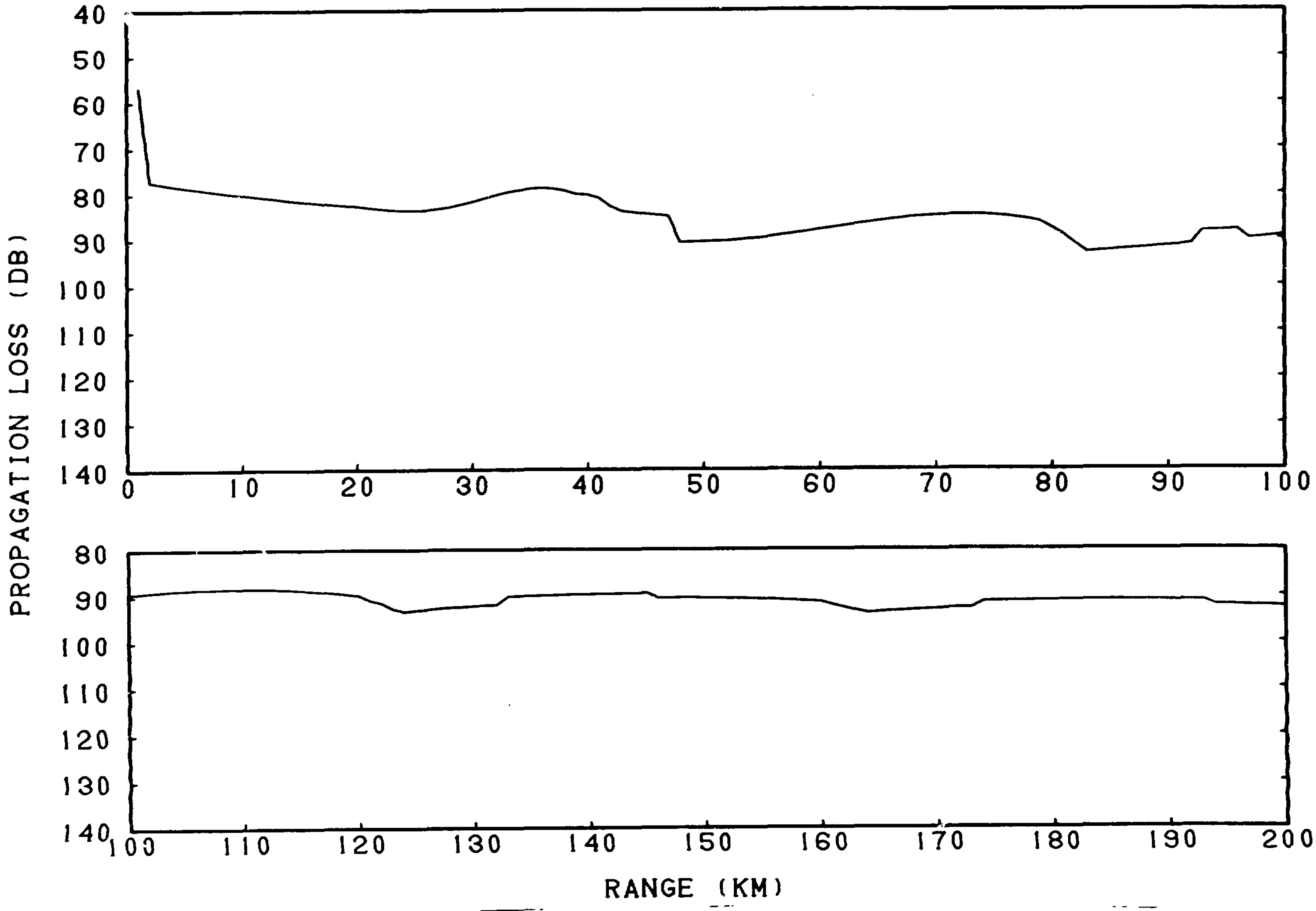
CONFIDENTIAL

(C) Figure IIB-74. FACT (Semi-coherent) Case IV, Bottom Loss = MGS Type 2, Frequency = 200 Hertz



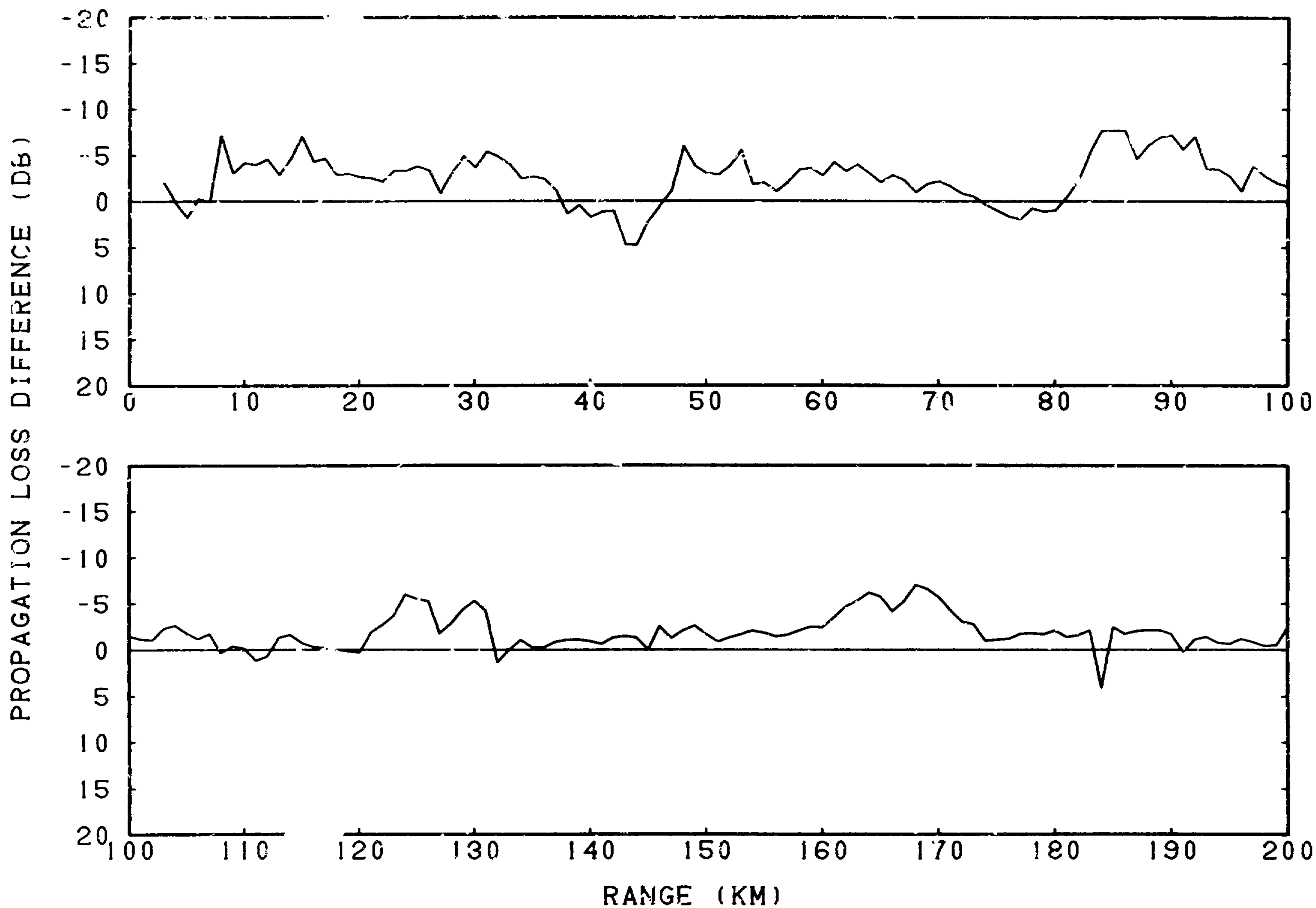
CONFIDENTIAL

(C) Figure IIB-75. FACT (Semi-coherent) Case IV, Bottom Loss = MGS Type 2, Frequency = 200 Hertz, Subtracted from Hays-Murphy Data, Case IV, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 200 Hertz



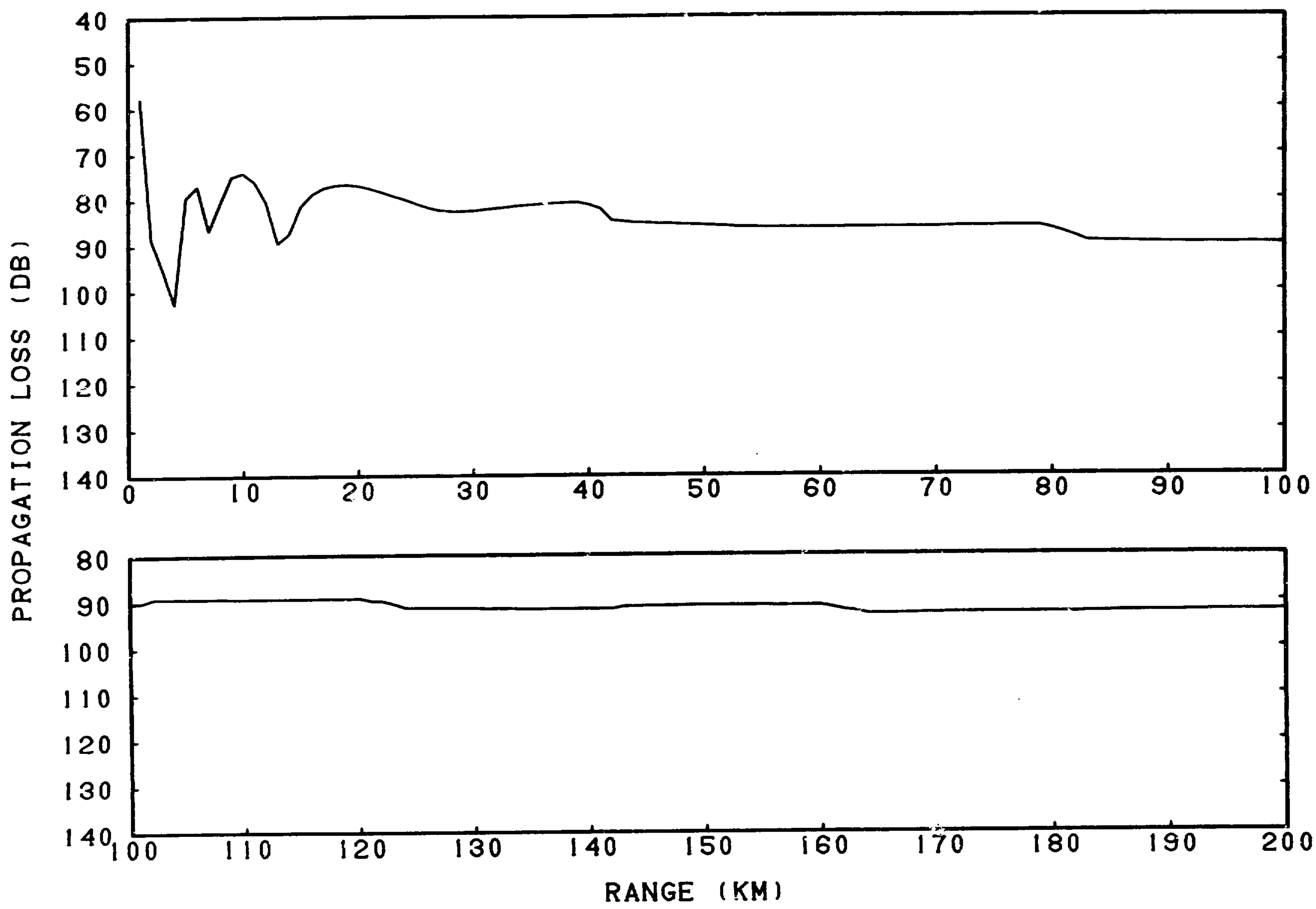
CONFIDENTIAL

(C) Figure IIB-76. FACT (Incoherent) Case IV, Bottom Loss = MGS Type 2, Frequency = 200 Hertz



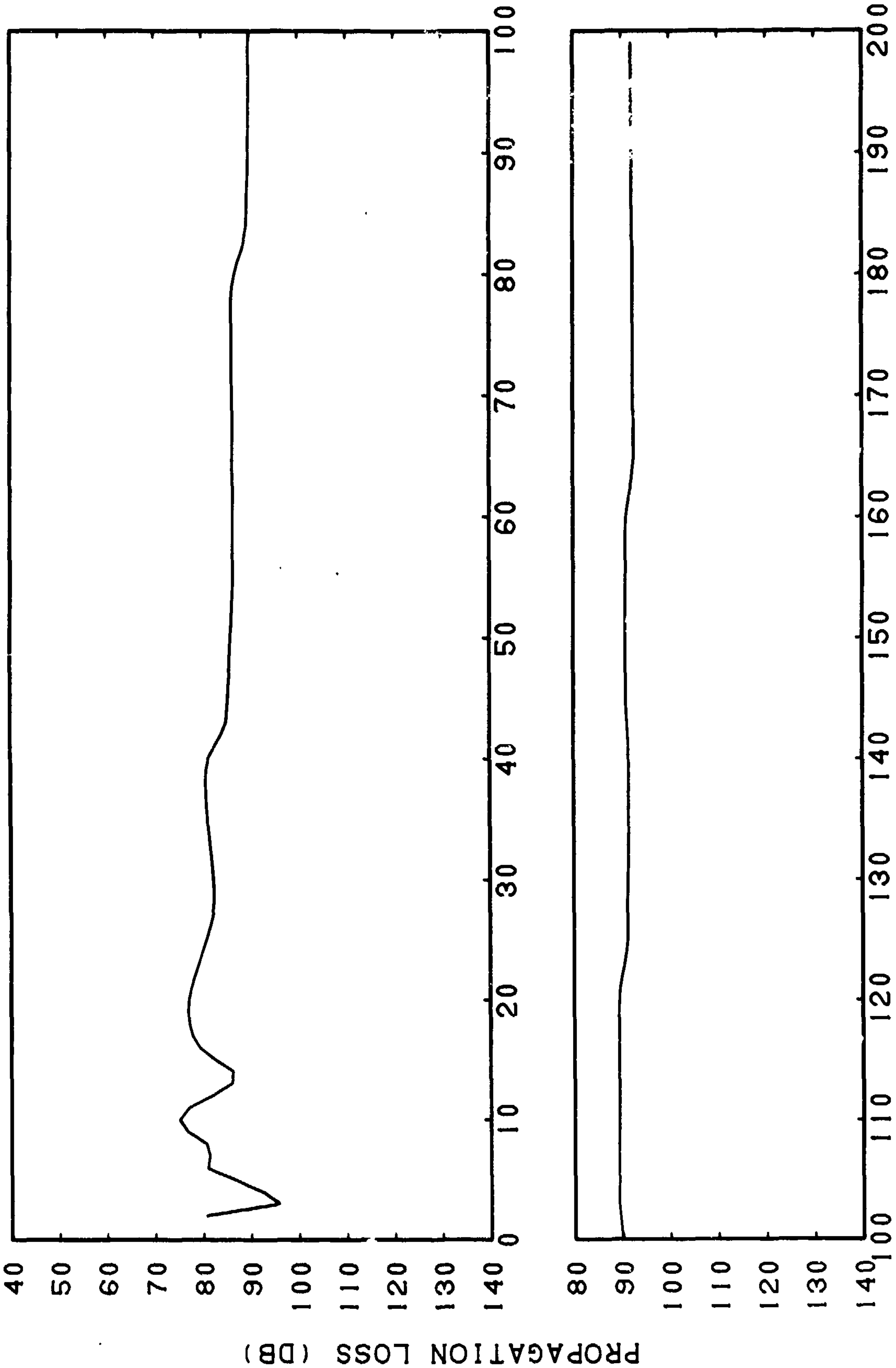
CONFIDENTIAL

(C) Figure IIB-77. FACT (Incoherent) Case IV, Bottom Loss = MGS Type 2, Frequency = 200 Hertz, Subtracted from Hays-Murphy Data, Case IV, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 200 Hertz



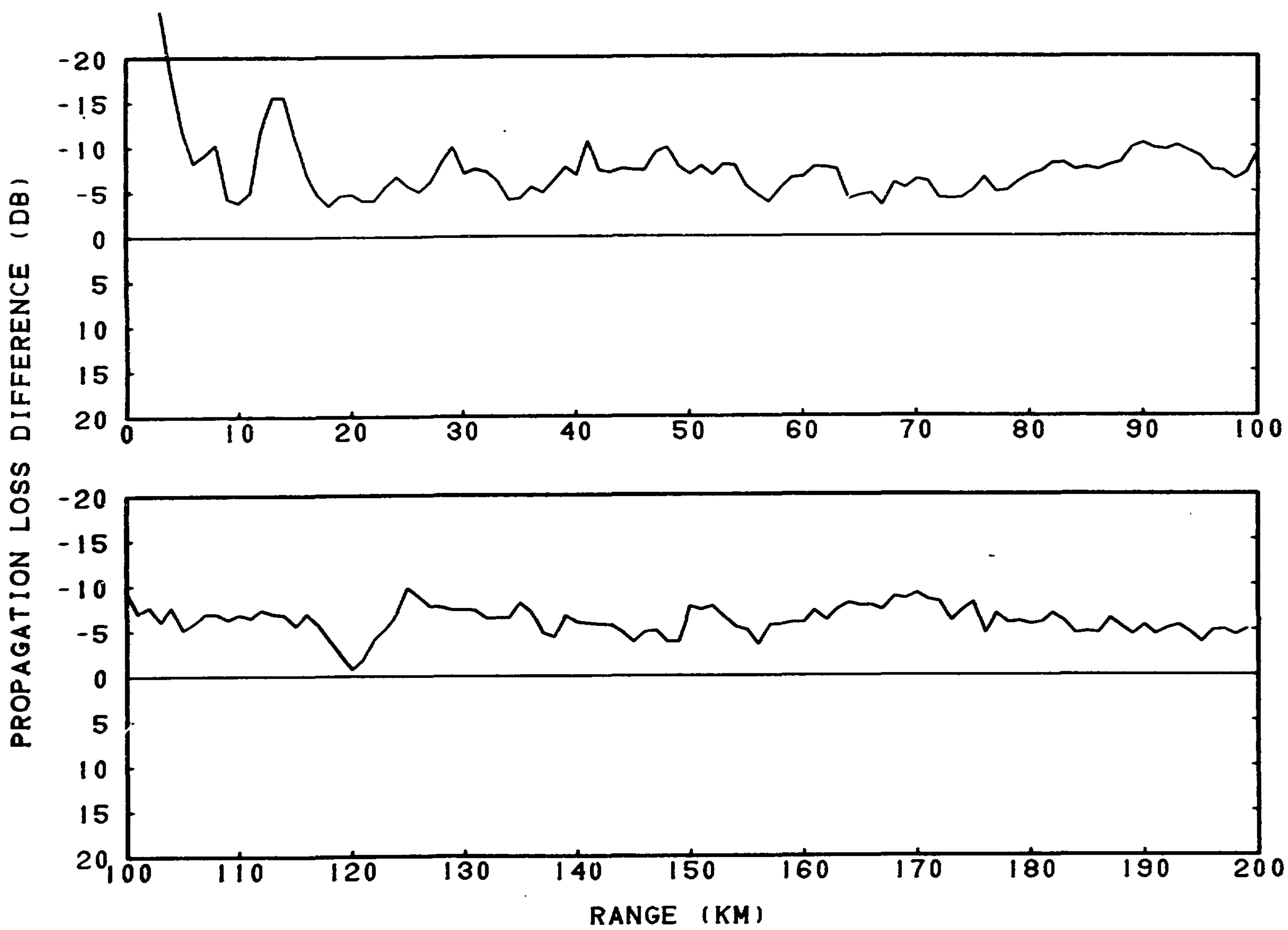
CONFIDENTIAL

(C) Figure IIB-78. FACT (Coherent) Case V, Bottom Loss = MGS Type 2, Frequency = 35 Hertz



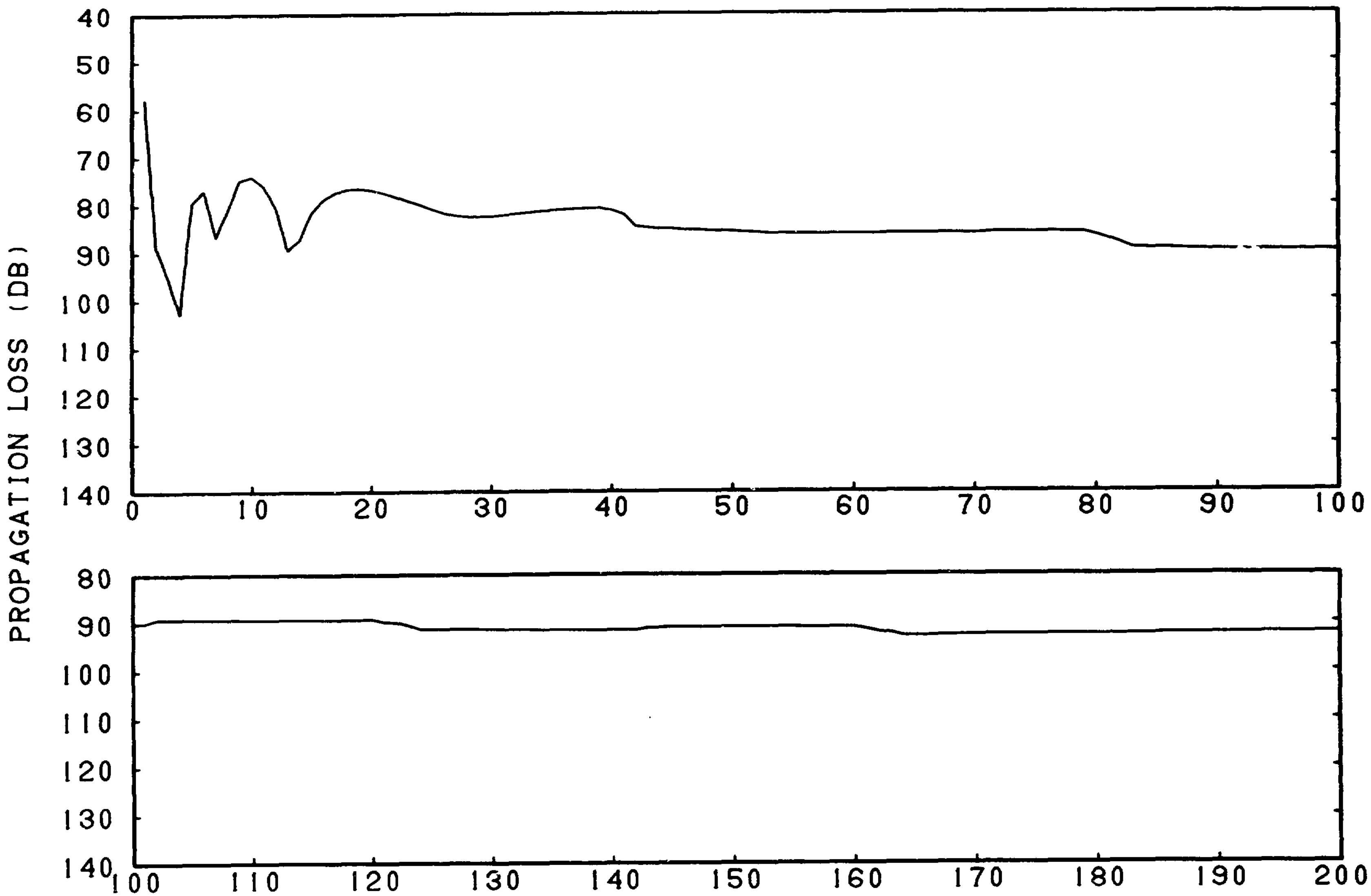
CONFIDENTIAL

(C) Figure IIB-79. FACT (Coherent) Case V, Bottom Loss = MGS Type 2, Frequency = 35 Hertz, Sliding Averages of 3 Points (2.00 Kilometer)



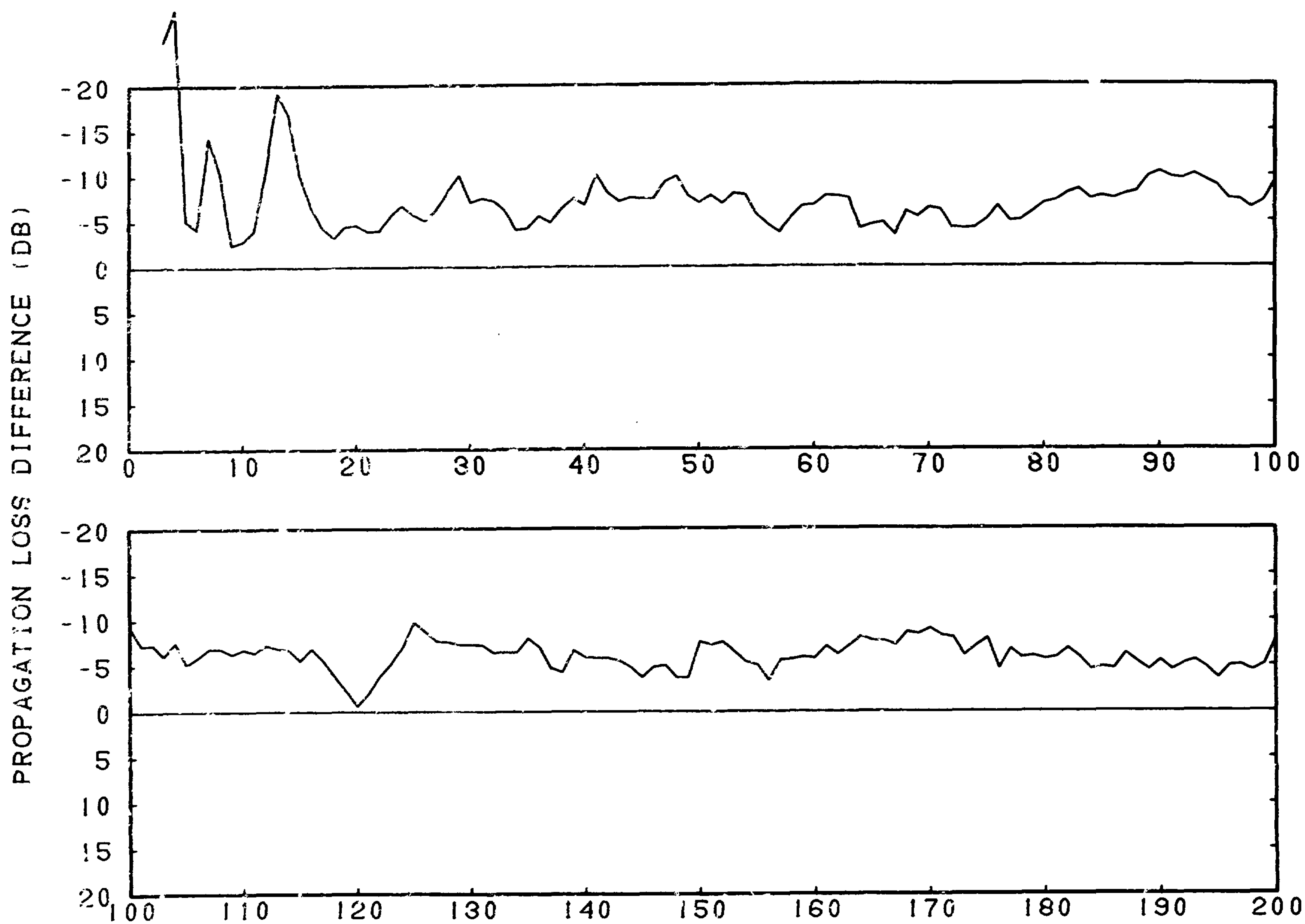
CONFIDENTIAL

(C) Figure IIB-80. Smoothed FACT (Coherent) Case V, Bottom Loss = MGS Type 2, Frequency = 35 Hertz, Subtracted from Hays-Murphy Data, Case V, Source Depth = 80 Feet, Receiver Depth = 350 Feet, Frequency = 35 Hertz



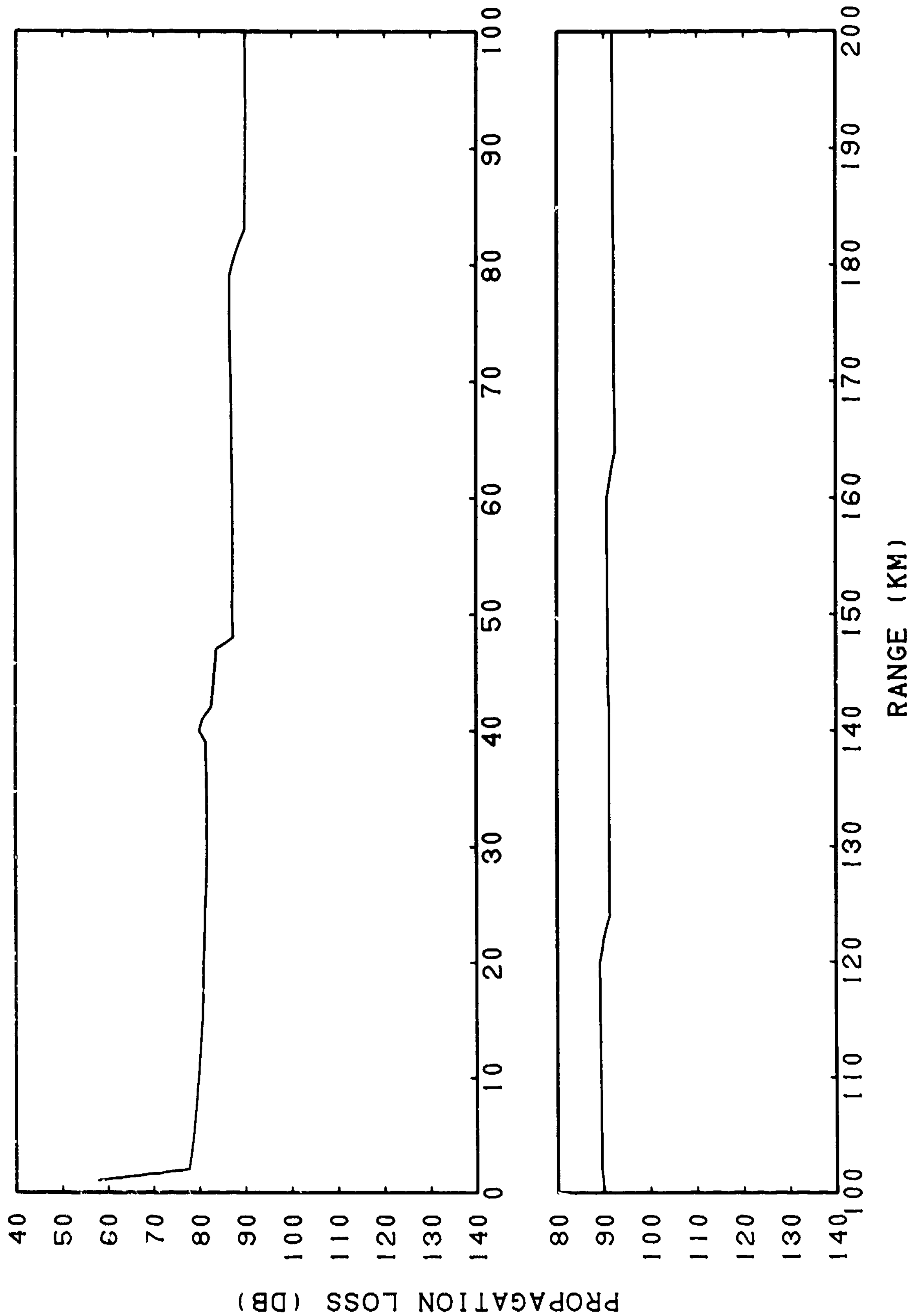
CONFIDENTIAL

(C) Figure IIB-81. FACT (Semi-coherent) Case V, Bottom Loss = MGS Type 2, Frequency = 35 Hertz, Source Depth = 80 Feet, Receiver Depth = 350 Feet



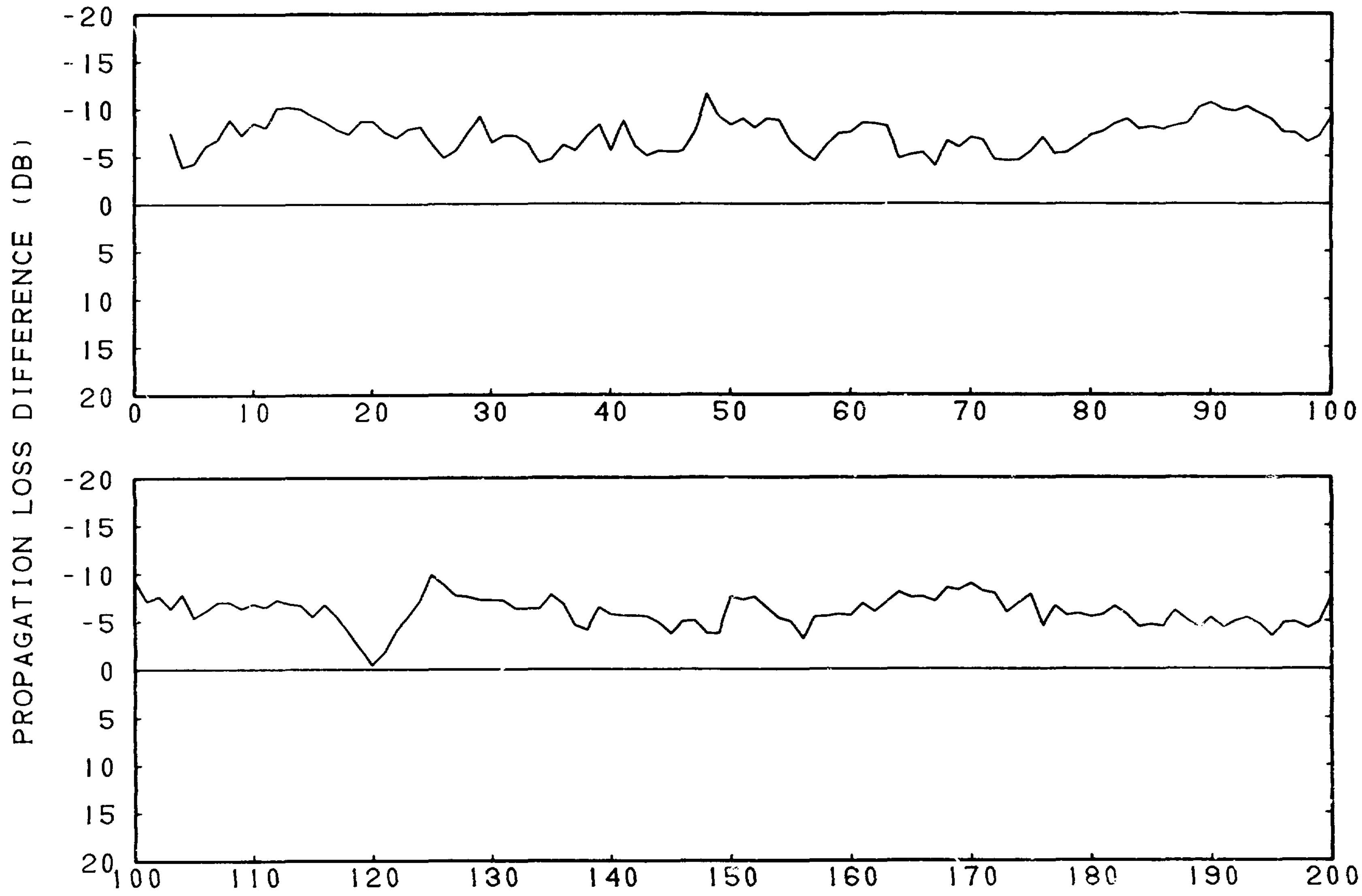
CONFIDENTIAL

(C) Figure IIB-82. FACT (Semi-coherent) Case V, Bottom Loss = MGS Type 2, Frequency = 35 Hertz, Subtracted from Hays-Murphy Data, Case V, Source Depth = 80 Feet, Receiver Depth = 350 Feet, Frequency = 35 Hertz



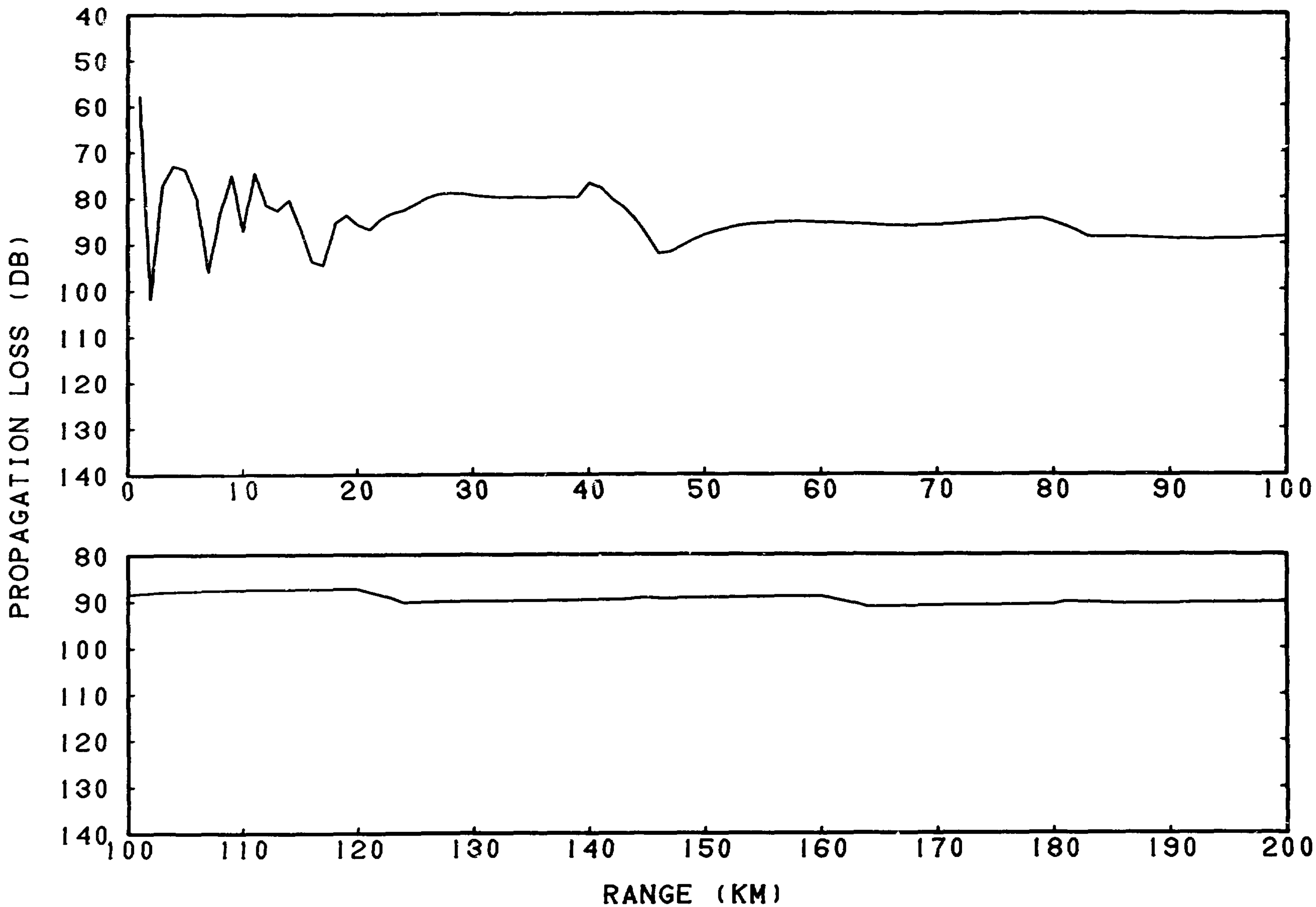
CONFIDENTIAL

(C) Figure IIB-83. FACT (Incoherent) Case V, Bottom Loss = MGS Type 2, Frequency = 35 Hertz



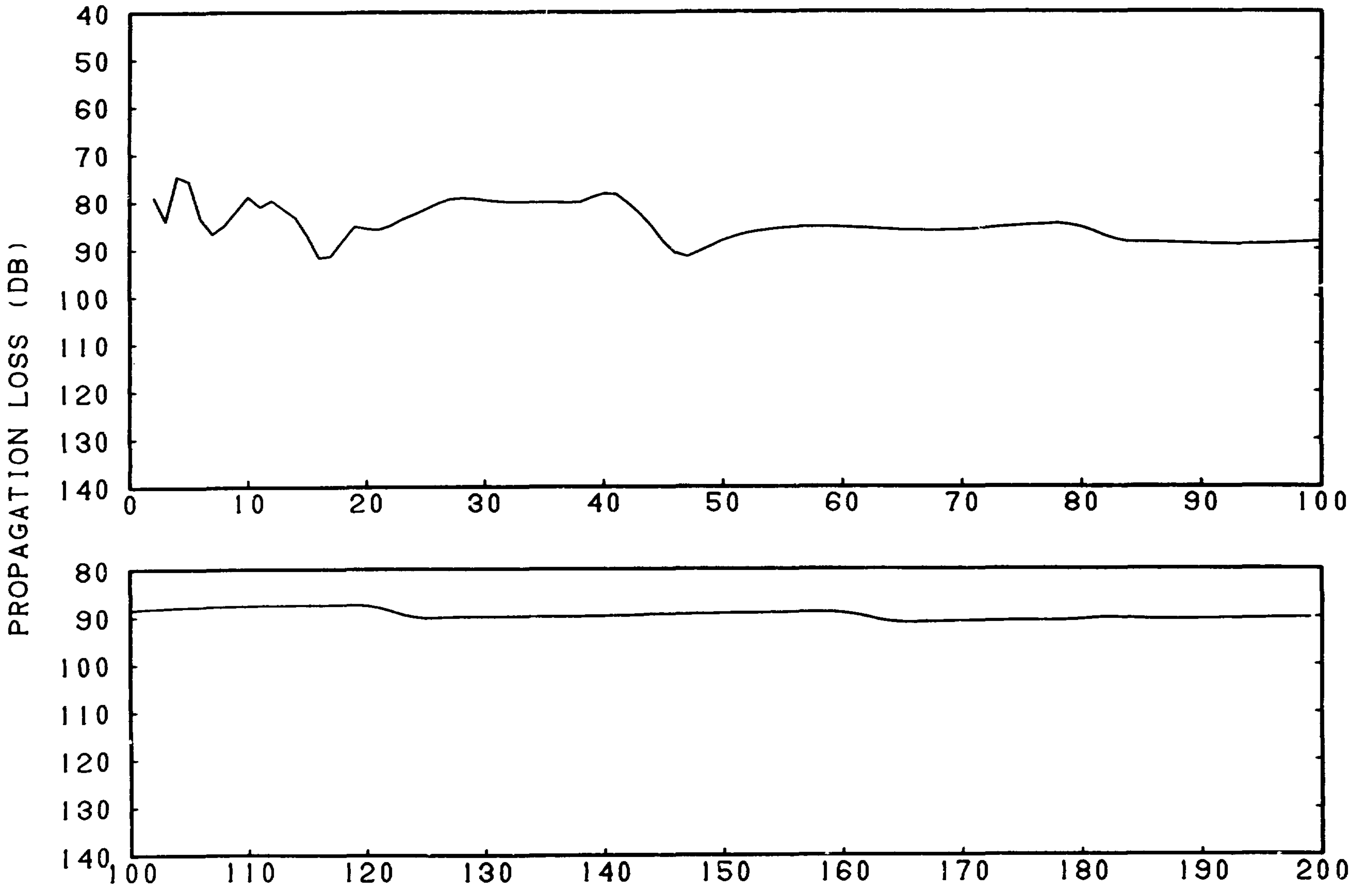
CONFIDENTIAL

(C) Figure IIB-84. FACT (Incoherent) Case V, Bottom Loss = MGS Type 2, Frequency = 35 Hertz, Subtracted from Hays-Murphy Data, Case V, Source Depth = 80 Feet, Receiver Depth = 350 Feet, Frequency = 35 Hertz



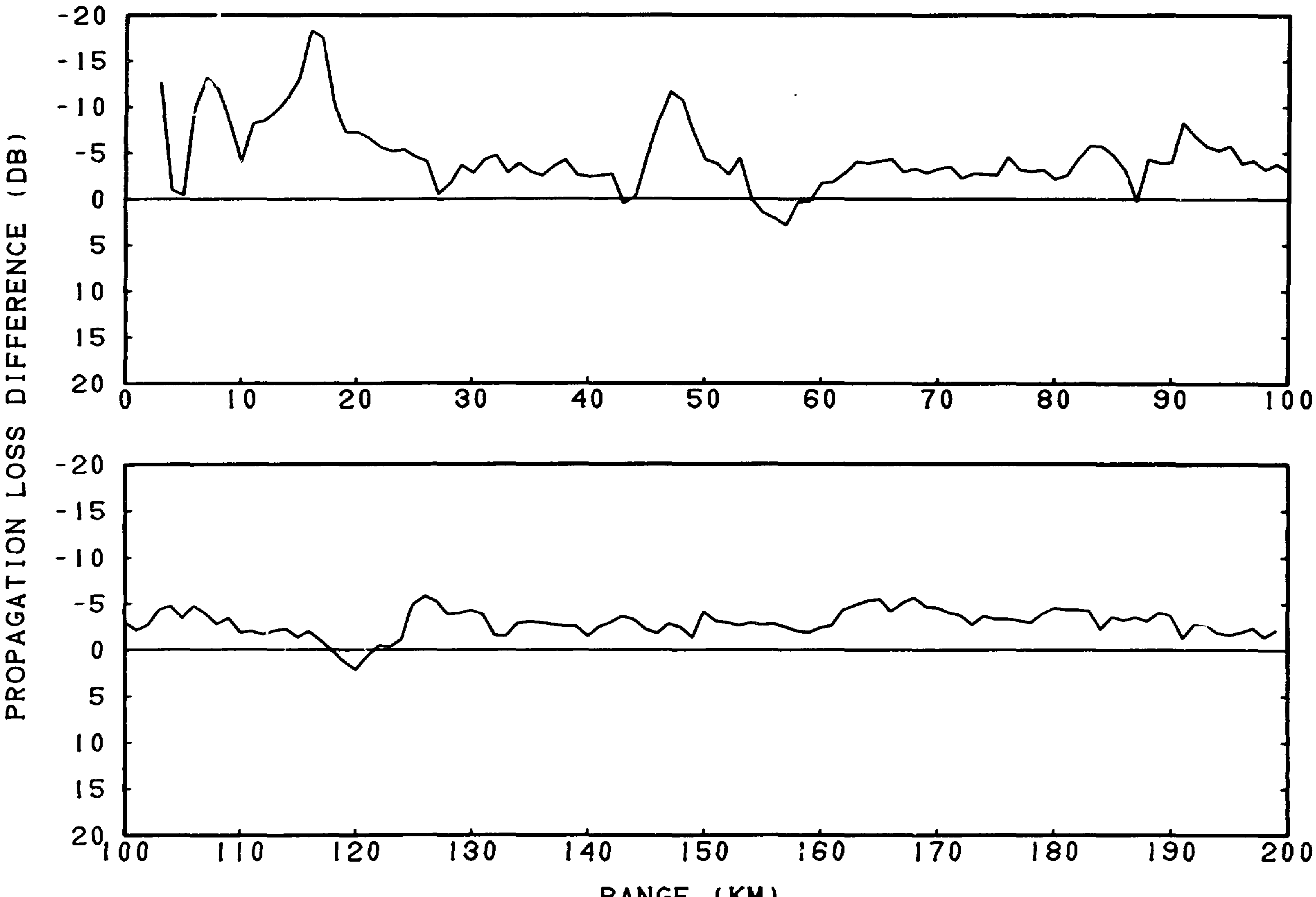
CONFIDENTIAL

(C) Figure IIB-85. FACT (Coherent) Case VI, Bottom Loss = MGS Type 2, Frequency = 100 Hertz



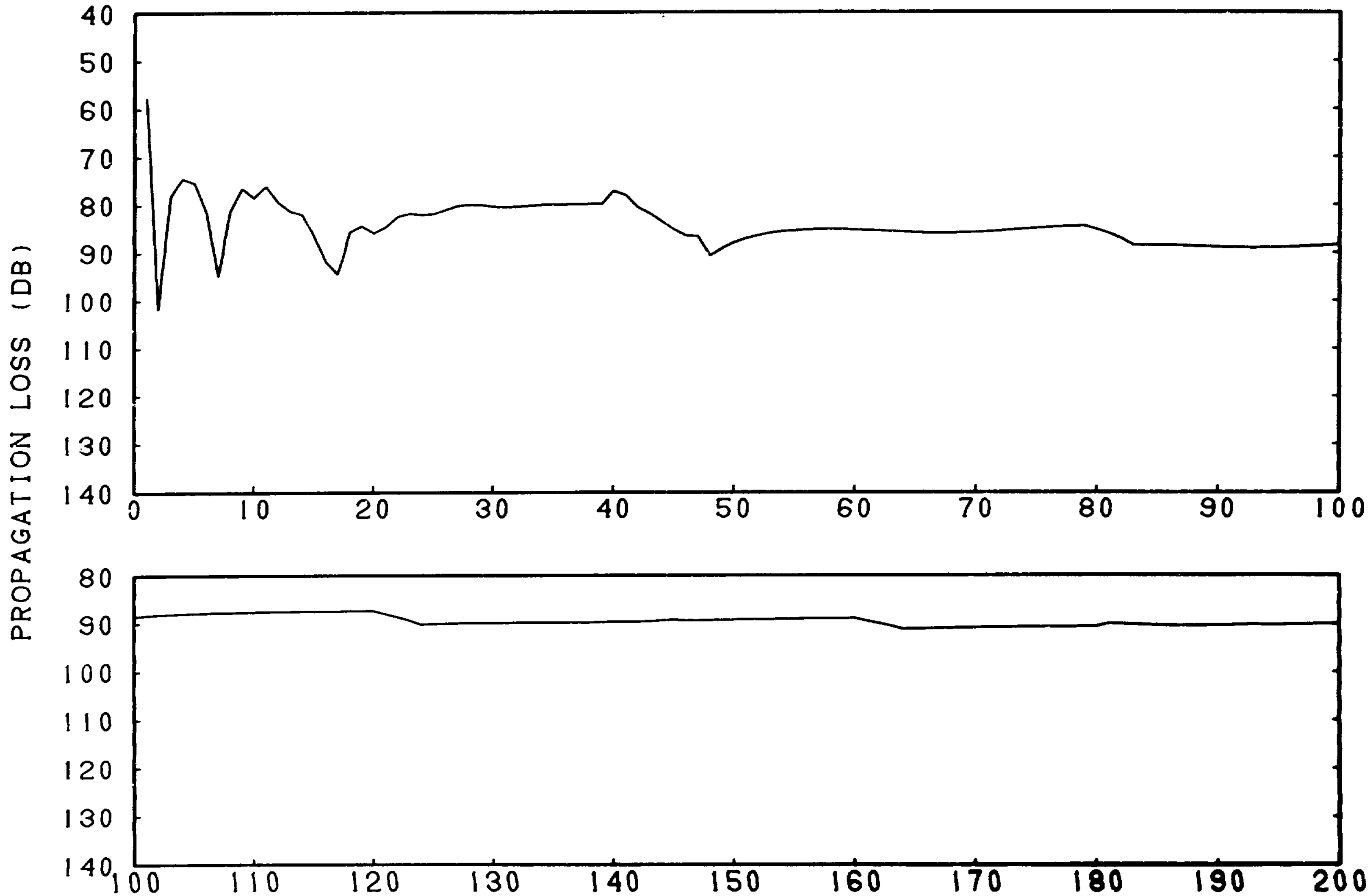
CONFIDENTIAL

(C) Figure IIB-86. FACT (Coherent) Case VI, Bottom Loss = MGS Type 2, Frequency = 100 Hertz, Sliding Averages of 3 Points (2.00 Kilometer)



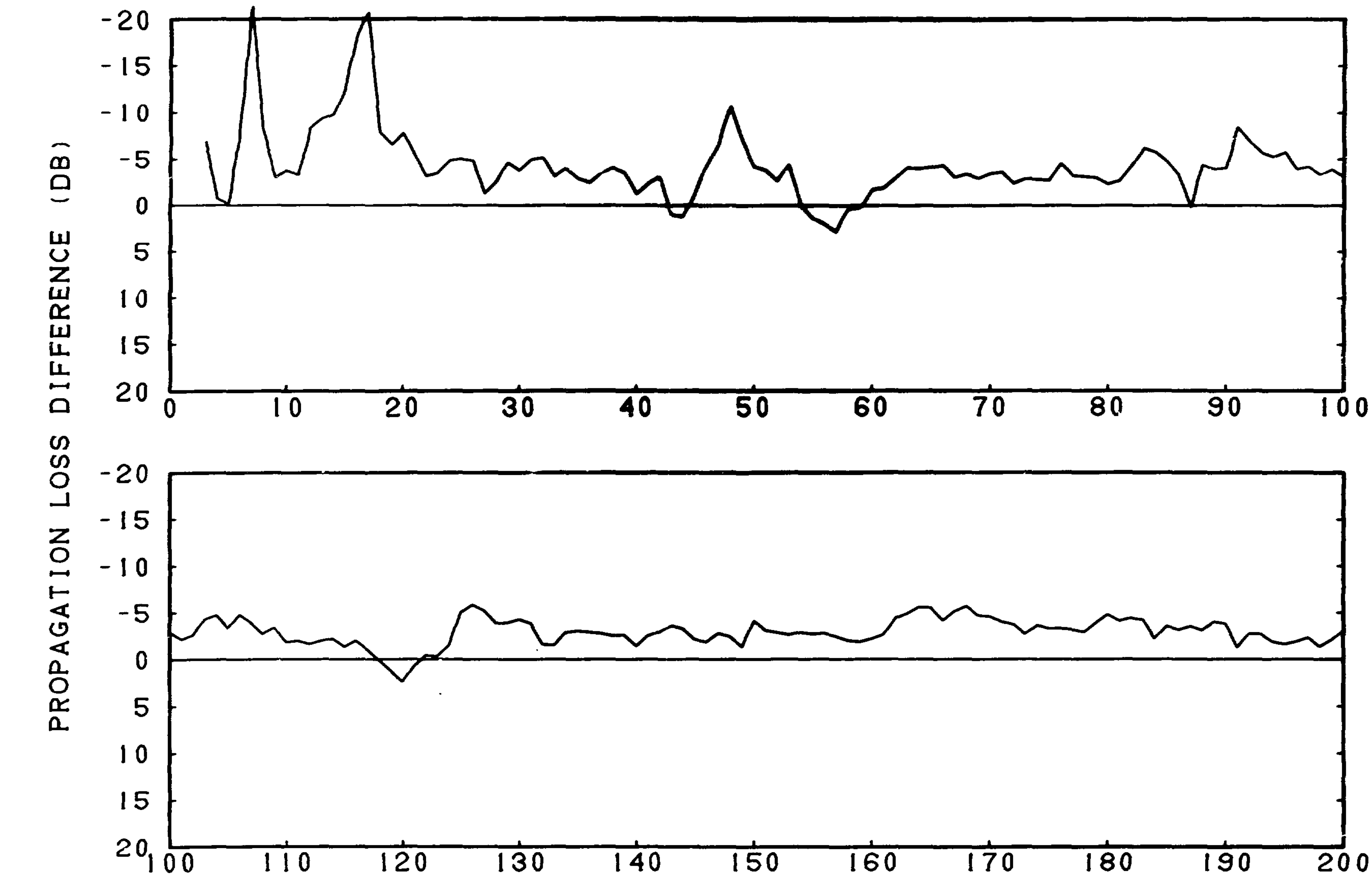
CONFIDENTIAL

(C) Figure IIB-87. Smoothed FACT (Coherent) Case VI, Bottom Loss = MGS Type 2, Frequency = 100 Hertz, Subtracted from Hays-Murphy Data, Case VI, Source Depth = 80 Feet, Receiver Depth = 350 Feet, Frequency = 100 Feet



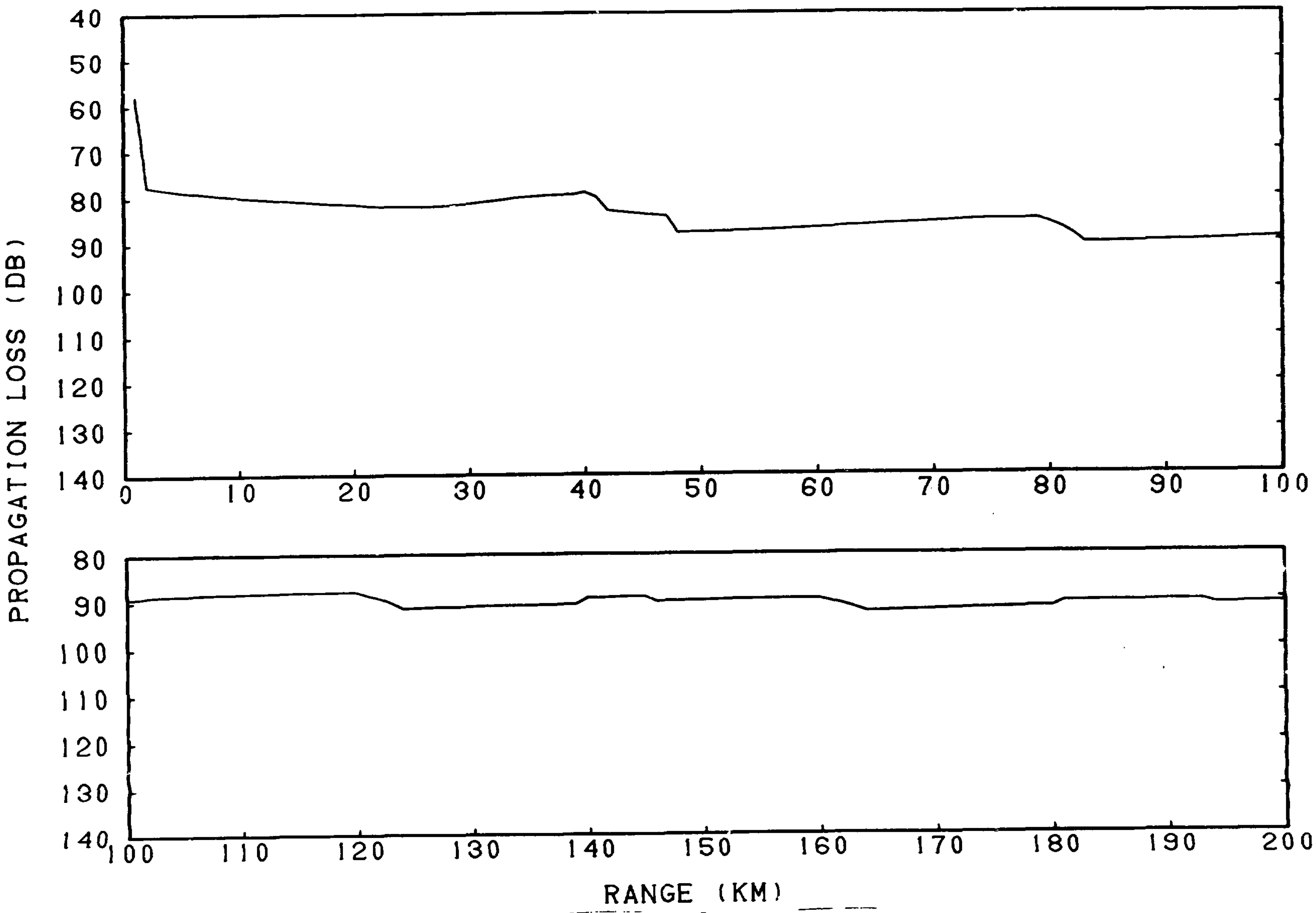
CONFIDENTIAL

(C) Figure IIB-88. FACT (Semi-coherent) Case VI, Bottom Loss = MGS Type 2, Frequency = 100 Hertz, Source Depth = 80 Feet, Receiver Depth = 350 Feet



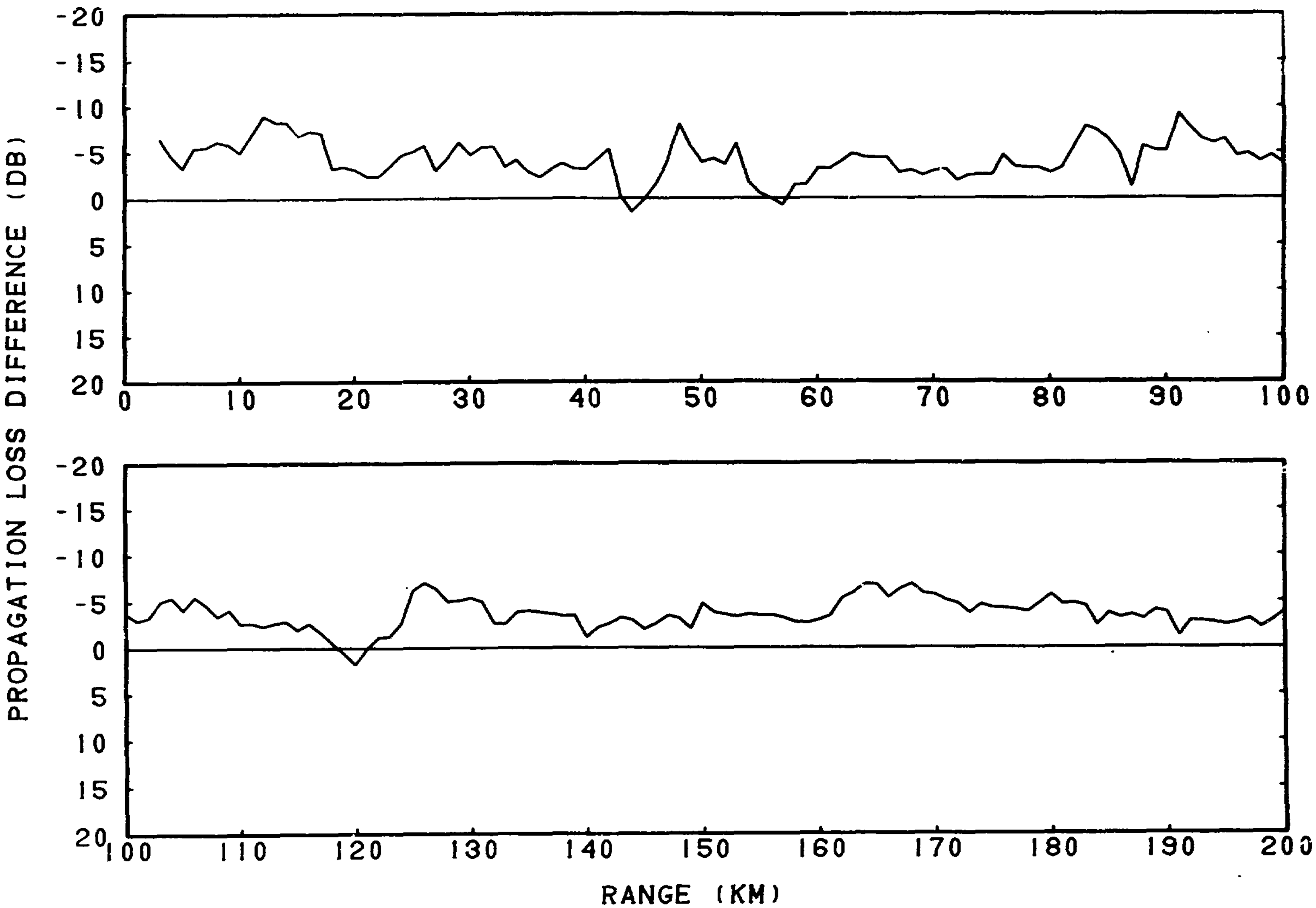
CONFIDENTIAL

(C) Figure IIB-89. FACT (Semi-coherent) Case VI, Bottom Loss = MGS Type 2, Frequency = 100 Hertz, Subtracted from Hays-Murphy Data, Case VI, Source Depth = 80 Feet, Receiver Depth = 350 Feet, Frequency = 100 Hertz



CONFIDENTIAL

(C) Figure IIB-90. FACT (Incoherent) Case VI, Bottom Loss = MGS Type 2, Frequency = 100 Hertz



CONFIDENTIAL

(C) Figure IIB-91. FACT (Incoherent) Case VI, Bottom Loss = MGS Type 2, Frequency = 100 Hertz, Subtracted from Hays-Murphy Data, Case VI, Source Depth = 80 Feet, Receiver Depth = 350 Feet, Frequency = 100 Hertz

Appendix IIC. (U) Accuracy Assessment of FACT PL9D Compared to PARKA Experimental Data

PARKA (U)

Environment (U)

(C) The sound speed profile for the PARKA environment is plotted and tabulated in Figure IIC1. This profile exhibits a surface duct to a depth of 262 ft (80 m) and a deep sound channel to a depth of 14,594 ft (4448 m). The depth excess is 3452 ft (1052 m).

(C) Two sets of bottom loss tables were used as input to the FACT PL9D model. The first is FACT's internal FNOC/NOO bottom loss found in subroutine BTMLOS, and in the two cases examined, a type 3 bottom was found to pertain at the site of the receiver. The second set of curves are the MGS curves found in subroutine MGSBL in the RAYMODE X model and here a type 6 bottom was found from the bottom loss province charts. These latter curves were input into FACT PL9D from an external table of 91 values. The FNOC/NOO bottom loss curves for 50 and 400 Hz are found in Figures IIC2 and IIC3 and Tables IIC1 and IIC2. The corresponding MGS curves are presented in Figures IIC4 and IIC5 and Tables IIC3 and IIC4, respectively. At 50 Hz, the FACT internal bottom loss has a critical angle of 12 degrees, a 1 dB loss at 15 degrees and 10 dB loss at normal incidence. The MGS result at 50 Hz has a critical angle of 9 degrees, 1.6 dB loss at 15 degrees and 8.1 dB at normal incidence. At 400 Hz the FACT internal FNOC/NOO shows a constant 3 dB loss to 14 degrees, 3.3 dB at 15 degrees and 11 dB at normal incidence. MGS results for 400 Hz are 7.5 dB loss at zero degrees, 11.3 dB at 15 degrees, and 15.9 dB at normal incidence.

Test Cases (U)

(C) Two test cases were chosen for the PARKA environment:

Case I. Source Depth = 500 ft (152.4 m), Receiver Depth = 300 ft (91.4 m), Frequency = 50 Hz.

Case II. Source Depth = 500 ft (152.4 m), Receiver Depth = 300 ft (91.4 m), Frequency = 400 Hz.

(C) For both cases, source and receiver are below the surface duct. Due to the large depth excess, convergence zone (CZ) propagation is exhibited by the PARKA data in both cases; in Case I, three convergence zones were observed and in Case II, two zones were observed (range was sufficient for a third zone but it was not evident). In both cases, the flat bottom and single profile assumptions inherent in the FACT PL9D model held to a range of 200 km. The PARKA experimental data for these cases are found in Figures IIC6 and IIC7.

Accuracy Assessment Results (U)

(U) The accuracy assessment procedures were followed as outlined in section 1.1 and described in detail in Volume I of this series. The following types of figures were produced for each case: (1) FACT PL9D output using the coherent option, (2) the coherent result smoothed by application of a 2 km window running average, (3) the smoothed coherent result subtracted from PARKA data, (4) FACT PL9D output using the semi-coherent option, (5) the semi-coherent result subtracted from PARKA data, (6) FACT PL9D output using the incoherent option, and (7) the incoherent result subtracted from PARKA data. For each case these seven curves are given first for FACT PL9D run with its own internal FNOC/NOO bottom loss and then for FACT PL9D run using RAYMODE X's MGS bottom loss curves. These results are given in Figures IIC8-IIC21 for Case I and Figures IIC22-IIC35 for Case II.

(U) The means and standard deviations of difference between PARKA data and FACT PL9D model outputs (in dB) for which the model used the FNOC/NOO bottom loss are given in Table IIC5 for Case I and Table IIC6 for Case II. Corresponding results in which MGS bottom loss was used are given in Table IIC7 and IIC8. Note that a positive mean value indicates that the model exhibits less loss than the PARKA experimental data and is too optimistic; conversely, a negative mean value indicates greater loss for model result than for the experimental data and the model prediction is therefore too pessimistic. Optimistic model results lead to prediction of detection ranges which are greater than should be predicted (i.e., greater than the experimental results) and vice versa for pessimistic prediction.

(C) The following observations can be made with regard to the 50 Hz results (i.e., Case I): (1) The results are somewhat sensitive to the coherence option selected; a slight advantage in mean value of the difference between PARKA data and the FACT output is gained by avoiding the incoherent option in the first bottom bounce region, but this is nullified by the small standard deviation associated with the incoherent option. Overall, no significant advantage is evident with regard to coherence option. (2) The FACT and RAYMODE bottom loss options do not lead to substantially different results. Indeed, bottom loss options account for differences between 0 and 1 dB in values of μ and σ. This is not surprising, since the two bottom loss tables differ by zero dB to 9 degrees and by less than 1 dB per bounce past 9 degrees. (3) Agreement between PARKA data and FACT PL9D in the first convergence zone gives μ nearly equal to zero, $\sigma = 1.6$, in the second CZ μ nearly equal to zero, $\sigma = 3.7$ dB, and in the third convergence zone $\mu = -2.4$ dB, $\sigma = 4.6$ dB for the semi-coherent option. Thus, we see a gradual lessening of the agreement with range, as one would expect. (4) In the bottom bounce regions, consistently optimistic FACT PL9D model predictions are observed; clearly, the bottom loss was not great enough (i.e., a higher bottom type is indicated for FNOC area charts whereas for MGS only one bottom loss curve exists at 50 hertz regardless of bottom type and, therefore, a basic problem is found for the MGS bottom loss data base a lack of flexibility). We note the increasing discrepancy between experimental data and model prediction with range as indicated by the increase of μ with range. It should be noted that the standard deviation, however, reaches a maximum in the second bottom bounce region. For Case II (400 Hz) the means and standard deviations of the difference curves (PARKA experimental data minus FACT PL9D predictions) found in Tables IIC6 and IIC8 lead to the following conclusions: (1) The FACT bottom loss leads to better agreement with the data than the RAYMODE bottom loss (Note: a conclusion not to be generalized). (2) Through the second CZ (using FACT's bottom loss) the predictions are consistently optimistic by 1 to 3 dB in mean level. (3) The large standard deviation in the region from 127.5 to 200 km is due to the FACT PL9D prediction of a third convergence zone which was not evident in the PARKA data. (4) The disagreements in the first CZ are due to the model predicting a broader CZ.

(C) The figure of merit (FOM) versus detection range analysis for the two cases are given in Table IIC9 and IIC10, respectively, for the FACT PL9D model using the internal FNOC/NOO bottom loss. Corresponding Tables IIC11 and IIC12 apply to use of the MGS bottom loss in FACT PL9D. For Case I the following results are observed from FACT PL9D results using the FNOC bottom loss: (1) For FOM = 80 dB both the experimental data and the model predict a two-lobed first convergence zone, the detection ranges of which agree to within 0.5 km. (2) For FOM = 85 dB, start and end ranges of the first CZ agree to within 1 km between PARKA data and FACT PL9D; for the second CZ, PARKA gives a first lobe and FACT PL9D a second lobe; for the

third CZ, PARKA gives a double-lobed CZ while FACT PL9D fails to predict a CZ at this level. The PARKA data show complete detection coverage to 11 km and 60% coverage to 23 km. This is in contrast to the FACT PL9D semi-coherent prediction of total coverage to 6.5 km, 40% coverage to 22.5 km and total coverage between 36 and 45 km (optimistically). (3) At FOM = 90 dB, the FACT prediction is slightly pessimistic with respect to PARKA results for coherent and semi-coherent options in that PARKA gives greater percentage coverage to the first CZ (for which start ranges are identical) and 6 km further detection after the first CZ; the second CZ is predicted three times wider than the PARKA observation, the third CZ is predicted as double-lobed by FACT, but single-lobed and narrower from PARKA. (4) For FOM = 95 dB, FACT PL9D predicts better detection coverage than given by PARKA data at long ranges (100 km), but predicts 20% coverage from 10.5 to 33 km compared to continuous coverage from the PARKA data. Second CZ zone onset is 3 km less for FACT PL9D. (5) For FOM = 100 dB, FACT PL9D predicts much greater long range coverage than PARKA. Both have continuous coverage to past 100 km.

(C) For Case II (400 Hz) the following observations are made for (1) FOM = 80 dB. FACT predicts the presence of a first convergence zone not supported by PARKA results. (2) FOM = 85 dB. Continuous coverage to 9 km for PARKA, 6.5-8 km for FACT PL9D. First CZ start 2 km greater for PARKA and 4.5 km less at end (i.e., PARKA CZ is 1.5 km long, FACT CZ is 8 km long). (3) FOM = 90 dB. Predicted coverage by FACT PL9D semi-coherent much greater than that of PARKA; continuous coverage 8 km greater to 44.5, the first CZ is almost three times wider (despite zone onset agreement), the second CZ is twice as wide, and FACT predicts a double-lobed third CZ which was not observed in the PARKA experiment. For this FOM and greater, the difference between using FACT or RAYMODE bottom loss for the FACT prediction was great as reflected in detection coverage. For the most part, use of the FACT bottom loss led to greater agreement with PARKA data than did use of the RAYMODE bottom loss. (4) FOM = 100 dB. FACT PL9D is in basic agreement with PARKA to beyond the second CZ. The major discrepancy is the prediction by FACT of third CZ coverage, not observed from PARKA results.

(C) Overall, the following results are given for the comparison between PARKA experimental data and the FACT PL9D model: (1) FACT's own bottom loss leads to better agreement than do RAYMODE's at 400 Hz (at 50 Hz the differences are negligible). (2) FACT predicts zone onset of first and second convergence zones accurately with respect to PARKA data. (3) Second and third convergence zones predicted by FACT are too narrow compared to PARKA data. (4) FACT predicts optimistic coverage compared to PARKA results.

(U) Table IIC-1. Bottom Loss (dB) Versus Grazing Angle (degrees). FNOC Type 3. Frequency = 50 Hz.

Θ	BL
0	0
11	0
20	3.0
25	4.4
35	6.7
45	8.5
66	10.0
90	10.0

UNCLASSIFIED

(U) Table IIC-2. Bottom Loss (dB) Versus Grazing Angle (degrees). FNOC Type 3. Frequency = 400 Hz.

Θ	BL
0	3.0
13	3.0
20	5.3
35	8.7
45	10.3
53	11.0
90	11.0

UNCLASSIFIED

(U) Table IIC-3. Bottom Loss (dB) Versus Grazing Angle (degrees).
MGS Type 6. Frequency = 50 Hz.

O	BL	O	BL	O	BL	O	BL	O	BL	O	BL	O	BL
0	0	13	1.36	26	4.49	39	6.57	52	7.84	65	8.45	78	8.51
1	0	14	1.64	27	4.68	40	6.70	53	7.91	66	8.47	79	8.49
2	0	15	1.92	28	4.87	41	6.82	54	7.97	67	8.49	80	8.48
3	0	16	2.19	29	5.05	42	6.93	55	8.03	68	8.51	81	8.45
4	0	17	2.45	30	5.23	43	7.04	56	8.09	69	8.52	82	8.43
5	0	18	2.70	31	5.40	44	7.15	57	8.14	70	8.53	83	8.40
6	0	19	2.95	32	5.57	45	7.25	58	8.19	71	8.54	84	8.37
7	0	20	3.19	33	5.73	46	7.34	59	8.24	72	8.55	85	8.33
8	0	21	3.42	34	5.88	47	7.44	60	8.28	73	8.55	86	8.30
9	0.14	22	3.65	35	6.03	48	7.53	61	8.32	74	8.55	87	8.26
10	0.46	23	3.87	36	6.17	49	7.61	62	8.36	75	8.54	88	8.21
11	0.77	24	4.08	37	6.31	50	7.69	63	8.39	76	8.54	89	8.17
12	1.07	25	4.29	38	6.45	51	7.77	64	8.42	77	8.52	90	8.12

UNCLASSIFIED

(U) Table IIC-4. Bottom Loss (dB) Versus Grazing Angle (degrees). MGS Type 6. Frequency = 400 Hz.

Θ	BL	Θ	BL	Θ	BL	Θ	BL	Θ	BL	Θ	BL	Θ	BL
0	7.50	13	11.15	26	13.12	39	14.39	52	15.20	65	15.69	78	15.91
1	8.37	14	11.34	27	13.24	40	14.46	53	15.25	66	15.72	79	15.92
2	8.85	15	11.52	28	13.35	41	14.54	54	15.30	67	15.74	80	15.92
3	9.19	16	11.69	29	13.46	42	14.61	55	15.34	68	15.76	81	15.93
4	9.44	17	11.86	30	13.57	43	14.68	56	15.38	69	15.78	82	15.93
5	9.65	18	12.02	31	13.67	44	14.75	57	15.42	70	15.80	83	15.93
6	9.83	19	12.18	32	13.77	45	14.81	58	15.46	71	15.82	84	15.94
7	9.98	20	12.33	33	13.87	46	14.87	59	15.50	72	15.84	85	15.93
8	10.11	21	12.47	34	13.96	47	14.93	60	15.53	73	15.85	86	15.93
9	10.28	22	12.61	35	14.05	48	14.99	61	15.57	74	15.87	87	15.93
10	10.52	23	12.74	36	14.14	49	15.05	62	15.60	75	15.88	88	15.92
11	10.74	24	12.87	37	14.23	50	15.10	63	15.63	76	15.89	89	15.92
12	10.95	25	13.00	38	14.31	51	15.15	64	15.66	77	15.90	90	15.91

UNCLASSIFIED

(U) Table IIC-3. Bottom Loss (dB) Versus Grazing Angle (degrees).
MGS Type 6. Frequency = 50 Hz.

O	BL	O	BL	O	BL	O	BL	O	BL	O	BL	O	BL
0	0	13	1.36	26	4.49	39	6.57	52	7.84	65	8.45	78	8.51
1	0	14	1.64	27	4.68	40	6.70	53	7.91	66	8.47	79	8.49
2	0	15	1.92	28	4.87	41	6.82	54	7.97	67	8.49	80	8.48
3	0	16	2.19	29	5.05	42	6.93	55	8.03	68	8.51	81	8.45
4	0	17	2.45	30	5.23	43	7.04	56	8.09	69	8.52	82	8.43
5	0	18	2.70	31	5.40	44	7.15	57	8.14	70	8.53	83	8.40
6	0	19	2.95	32	5.57	45	7.25	58	8.19	71	8.54	84	8.37
7	0	20	3.19	33	5.73	46	7.34	59	8.24	72	8.55	85	8.33
8	0	21	3.42	34	5.88	47	7.44	60	8.28	73	8.55	86	8.30
9	0.14	22	3.65	35	6.03	48	7.53	61	8.32	74	8.55	87	8.26
10	0.46	23	3.87	36	6.17	49	7.61	62	8.36	75	8.54	88	8.21
11	0.77	24	4.08	37	6.31	50	7.69	63	8.39	76	8.54	89	8.17
12	1.07	25	4.29	38	6.45	51	7.77	64	8.42	77	8.52	90	8.12

UNCLASSIFIED

(U) Table IIC-4. Bottom Loss (dB) Versus Grazing Angle (degrees).
MGS Type 6. Frequency = 400 Hz.

Θ	BL	Θ	BL	Θ	BL	Θ	BL	Θ	BL	Θ	BL	Θ	BL
0	7.50	13	11.15	26	13.12	39	14.39	52	15.20	65	15.69	78	15.91
1	8.37	14	11.34	27	13.24	40	14.46	53	15.25	66	15.72	79	15.92
2	8.85	15	11.52	28	13.35	41	14.54	54	15.30	67	15.74	80	15.92
3	9.19	16	11.69	29	13.46	42	14.61	55	15.34	68	15.76	81	15.93
4	9.44	17	11.86	30	13.57	43	14.68	56	15.38	69	15.78	82	15.93
5	9.65	18	12.02	31	13.67	44	14.75	57	15.42	70	15.80	83	15.93
6	9.83	19	12.18	32	13.77	45	14.81	58	15.46	71	15.82	84	15.94
7	9.98	20	12.33	33	13.87	46	14.87	59	15.50	72	15.84	85	15.93
8	10.11	21	12.47	34	13.96	47	14.93	60	15.53	73	15.85	86	15.93
9	10.28	22	12.61	35	14.05	48	14.99	61	15.57	74	15.87	87	15.93
10	10.52	23	12.74	36	14.14	49	15.05	62	15.60	75	15.88	88	15.92
11	10.74	24	12.87	37	14.23	50	15.10	63	15.63	76	15.89	89	15.92
12	10.95	25	13.00	38	14.31	51	15.15	64	15.66	77	15.90	90	15.91

UNCLASSIFIED

(C) Table IIC-5. Means (μ) and Standard Deviations (σ) of Differences Between PARKA Experimental Data and FACT PL9D Model Outputs (in dB). Source Depth = 500 ft., Receiver Depth = 300 ft., Frequency = 50 Hz. FNOC (i.e., FACT's Internal) Type 3 Bottom Loss Used in FACT PL9D Model Runs.

	1st Bottom Bounce Region 0-54 km		1st Convergence Zone 54-65 km		2nd Bottom Bounce Region 65-113.5 km		2nd Convergence Zone 113.5-120.5 km		3rd Bottom Bounce Region 120.5-167.5 km		3rd Convergence Zone 167.5-179 km		4th Bottom Bounce Region 179-200 km	
Model Output	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ
FACT Coherent	-0.5	4.5	-0.1	0.9	4.1	4.8	0.3	3.4	9.3	3.7	-2.4	4.3	11.7	2.4
FACT Semicoherent	-0.6	6.7	0.1	1.6	4.1	4.9	0.3	3.7	9.3	3.8	-2.4	4.6	11.6	2.4
FACT Incoherent	2.5	2.2	0.5	1.5	5.1	3.1	-0.6	3.9	8.6	4.0	-3.1	4.9	10.5	3.3

CONFIDENTIAL

(C) Table IIC-6. Means (μ) and Standard Deviations (σ) of Differences, Between PARKA Experimental Data and FACT PL9D Model Outputs (in DB) Source Depth = 500 ft., Receiver Depth = 300 ft., Frequency = 400 HZ FNOC (i.e., FACT's Internal) Type 3 Bottom Loss Used in FACT PL9D Model Runs.

	1st Bottom Bounce Region 0-54 km		1st Convergence Zone 54-59.5 km		2nd Bottom Bounce Region 59.5-107 km		2nd Convergence Zone 107-127.5 km		127.5-200 km	
Model Output	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ
FACT Coherent	-2.0	4.6	3.2	2.2	1.4	4.6	0.8	3.4	2.6	9.0
FACT Semicoherent	2.0	1.0	3.3	2.5	3.7	3.0	1.2	3.6	3.4	7.9
FACT Incoherent	2.0	1.0	3.3	2.6	3.7	2.9	1.1	2.6	3.6	7.7

CONFIDENTIAL

(C) Table IIC-7. Means (μ) and Standard Deviations (σ) of Differences Between PARKA Experimental Data and FACT PL9D Model Outputs (in dB). Source Depth = 500 ft., Receiver Depth = 300 ft., Frequency = 50 Hz. MGS (i.e., RAYMODE X's Internal) Type 6 Bottom Loss Used in FACT PL9D Model Runs.

	1st Bottom Bounce Region 0-54 km		1st Convergence Zone 54-65 km		2nd Bottom Bounce Region 65-113.5 km		2nd Convergence Zone 113.5-120.5 km		3rd Bottom Bounce Region 120.5-167.5 km		3rd Convergence Zone 167.5-179 km		4th Bottom Bounce Region 179-200 km	
Model Output	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ
FACT Coherent	-0.2	4.1	-0.1	0.8	3.6	4.9	-0.1	3.5	8.6	3.6	-2.5	4.3	10.9	2.9
FACT Semicoherent	-0.3	6.2	0.0	1.6	3.6	5.0	-0.1	3.8	8.5	3.6	-2.5	4.6	10.9	2.9
FACT Incoherent	2.5	1.9	0.4	1.5	4.4	3.1	-0.8	4.0	7.9	3.8	-3.2	4.9	10.0	3.5

CONFIDENTIAL

CONFIDENTIAL

(C) Table IIC-8. Means (μ) and Standard Deviations (σ) of Differences Between PARKA Experimental Data and FACT PL9D Model Outputs (in dB). Source Depth = 500 ft., Receiver Depth = 300 ft., Frequency = 400 Hz. MGS (i.e., RAYMODE X's Internal) Type 6 Bottom Loss Used in FACT PL9D Model Runs.

	1st Bottom Bounce Region 0-54 km		1st Convergence Zone 54-59.5 km		2nd Bottom Bounce Region 59.5-107 km		2nd Convergence Zone 107-127.5 km		127.5-200 km	
Model Output	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ
FACT Coherent	-9.7	5.0	2.0	3.6	-10.3	10.6	-1.3	7.3	-5.7	17.3
FACT Semicoherent	-4.8	1.1	2.5	3.7	-7.3	7.9	-0.9	6.9	-4.6	15.9
FACT Incoherent	-4.8	1.1	2.5	3.7	-7.2	7.9	-1.0	7.0	-4.5	15.8

CONFIDENTIAL

(C) Table IIC-9a. Detection Range[1a,b] (km) as a Function of Figure of Merit (FOM) for PARKA Experimental Data and FACT PL9D Predictions. FNOC (i.e., FACT's Internal) Type 3 Bottom Loss Used in FACT PL9D Model Runs. Source Depth = 500 ft., Receiver Depth = 300 ft., Frequency = 50 Hz.

Data Set	FOM (dB)	R_c[3]		First Convergence Zone: First Lobe Start	First Convergence Zone: First Lobe End	First Convergence Zone: Second Lobe Start	First Convergence Zone: Second Lobe End	
PARKA	80			58.0	59.0	60.5	62.5	
FACT Coherent[2]	80	5.0		58.5	58.5	61.0	62.5	
FACT Semicoherent and Incoherent	80	6.0		58.5	58.5	61.0	62.5	
PARKA	85	11.0	ZDC[4] 60%, 11-23 km	55.0	59.0	59.5	64.5	
FACT Coherent	85	6.5	ZDC 40%, 6.5-22.5 km 100% coverage, 36-45 km	55.0			64.5	
FACT Semicoherent and Incoherent	85	40.0		54.0			64.5	
PARKA	90	36.5	100% coverage, 40-46.5 km	53.5				100% coverage, 53.5-71.5 km
FACT Coherent	90	10.0	ZDC 50%, 10-32.5 km 100% coverage, 35-47.5 km	53.5			65.5	
FACT Semicoherent and Incoherent	90	71.5						
PARKA	95	74.5						
FACT Coherent	95	10.5	ZDC 20%, 10.5-33 km 100% coverage, 35-47.5 km					
FACT Semicoherent and Incoherent	95	150.0						
PARKA	100	125.0						
FACT Coherent	100	100.0	100% coverage except for three 1 km intervals at 11, 14, & 24 km					100% coverage from 25 to 200 km except for 100-104 km
FACT Semicoherent and Incoherent	100	>200.0						
PARKA	105	149.0						
FACT Coherent	105	>200.0						
FACT Semicoherent and Incoherent	105	>200.0						

1a. All detection ranges in kilometers.

1b. Range accuracy is ± 0.25 km.

2. FACT PL9D coherent results have been smoothed by a 2 km running average.

3. R_c = Range to which coverage is continuous.

4. ZDC = Zonal Detection Coverage (percent the FOM has a greater value than the propagation loss over the indicated interval.

(C) Table IIC-9b. Detection Range[1a,b] (km) as a Function of Figure of Merit (FOM) for PARKA Experimental Data and FACT PL9D Predictions. FNOC (i.e., FACT's Internal) Type 3 Bottom Loss Used in FACT PL9D Model Runs. Source Depth = 500 ft., Receiver Depth = 300 ft., Frequency = 50 Hz.

Data Set	FOM (dB)	Second Convergence Zone					Third Convergence Zone			
		First Lobe		Second Lobe			First Lobe		Second Lobe	
		Start	End	Start	End		Start	End	Start	End
PARKA	80									
FACT Coherent[2]	80									
FACT Semicoherent and Incoherent	80									
PARKA	85	115.5	117.5				171.0	171.0	173.0	174.5
FACT Coherent	85			120.0	125.0					
FACT Semicoherent and Incoherent	85			120.0	125.0					
PARKA	90	114.0			120.5		169.5			178.0
FACT Coherent	90	110.0			128.0		168.0	173.0	178.5	188.0
FACT Semicoherent and Incoherent	90	110.0			128.0		168.0	173.0	178.5	188.0
PARKA	95	110.0			123.5	100% coverage, 162-167.5 km				180.0
FACT Coherent	95	107.0				100% coverage from 107 to >200 km except for 136-148 km				
FACT Semicoherent and Incoherent	95					No coverage 150-160 km		174.0	176.0	191.0
PARKA	100				125.0	100% coverage resumes at 158 km				181.5
FACT Coherent	100									
FACT Semicoherent and Incoherent	100									
PARKA	105					No coverage, 149-155 km 100% coverage, 155->200 km				
FACT Coherent	105									
FACT Semicoherent and Incoherent	105									

1a. All detection ranges in kilometers.

1b. Range accuracy is ± 0.25 km.

2. FACT PL9D coherent results have been smoothed by a 2 km running average.

CONFIDENTIAL

(C) Table IIC-10a. Detection Range[1a,b] (km) as a Function of Figure of Merit (FOM) for PARKA Experimental Data and FACT PL9D Predictions. FNOC (i.e., FACT's Internal) Type 3 Bottom Loss Used in FACT PL9D Model Runs. Source Depth = 500 ft., Receiver Depth = 300 ft., Frequency = 400 Hz.

Data Set	FOM (dB)	R_c [3]		First Convergence Zone				
				First Lobe		Second Lobe		
				Start	End	Start	End	
PARKA	80							
FACT Coherent[2]	80	5.0		.		62.0	62.0	
FACT Semicoherent and Incoherent	80	5.5		58.0			63.0	
PARKA	85	9.0		58.0			59.5	
FACT Coherent	85	7.0		56.5			64.0	
FACT Semicoherent and Incoherent	85	8.0		56.0			64.0	
PARKA	90	36.5		55.5			59.0	
FACT Coherent	90	13.0	ZDC[4] 20%, 13-55 km	55.0			66.0	
FACT Semicoherent and Incoherent	90	44.5		55.5			65.0	
PARKA	95	50.0		54.0			66.0	
FACT Coherent	95	13.5	ZDC 75%, 13.5-55 km				69.0	
FACT Semicoherent and Incoherent	95	71.0						
PARKA	100	69.0					69.0	ZDC 15%, 69-108 km
FACT Coherent	100	73.0	100% coverage to 73 km except 1.5 km interval at 16 km					ZDC 20%, 73-111 km
FACT Semicoherent and Incoherent	100	89.0						ZDC 50%, 89-101 km **No coverage 101-111 km**
PARKA	105	129.0						
FACT Coherent	105	74.0						ZDC 70%, 74-98 km 100% coverage, 98-135 km
FACT Semicoherent and Incoherent	105	137.0						
PARKA	110	188.0						
FACT Coherent	110	147.0	No coverage, 89-90.5 km					
FACT Semicoherent and Incoherent	110	147.5						
PARKA	115	>200						
FACT Coherent	115	>200	**Anomalous dropout at 150 km**					
FACT Semicoherent and Incoherent	115	>200						

1a. All detection ranges in kilometers.

1b. Accuracy to ± 0.25 km.

2. FACT PL9D coherent data have been smoothed by a 2 km running average.

3. R_c = Range to which coverage is continuous.

4. ZDC = Zonal Detection Coverage **(percent the FOM is greater than the propagation loss over the indicated range interval).**

(C) Table IIC-10b. Detection Range[1a,b](km) as a Function of Figure of Merit (FOM) for PARKA Experimental Data and FACT PL9D Predictions. FNOC (i.e., FACT's Internal) Type 3 Bottom Loss Used in FACT PL9D Model Runs. Source Depth=500 ft., Receiver Depth=300 ft., Frequency=400 HZ

Data Set	FOM (dB)	Second Convergence Zone First Lobe Start	Second Convergence Zone First Lobe End	Second Convergence Zone Second Lobe Start	Second Convergence Zone Second Lobe End		Third Convergence Zone First Lobe Start	Third Convergence Zone First Lobe End	Third Convergence Zone Second Lobe Start	Third Convergence Zone Second Lobe End
PARKA	85									
FACT Coherent[2]	85									
FACT Semicoherent and Incoherent	85									
PARKA	90	114.5			120.0					
FACT Coherent	90	113.0			126.0		171.0	173.0	181.5	185.0
FACT Semicoherent and Incoherent	90	113.0			126.0		171.0	173.0	181.5	185.0
PARKA	95	110.5			127.0					
FACT Coherent	95	112.0			128.0		169.0	174.0	178.5	189.0
FACT Semicoherent and Incoherent	95	112.0			128.0		169.0	174.0	178.5	189.0
PARKA	100	108.0			128.0	3 km coverage at 165 km				
FACT Coherent	100	111.0			131.0		168.0	175.0	177.5	191.0
FACT Semicoherent and Incoherent	100	111.0			131.0		168.0	175.0	177.5	191.0
PARKA	105				129.0	ZDC[3] 60%, 129-183 km No coverage past 183 km				
FACT Coherent	105				135.0	ZDC 30%, 135-167 km	167.0			195.0
FACT Semicoherent and Incoherent	105				137.0	ZDC 50%, 137-143 km No coverage, 143-167 km	167.0	175.5	177.0	195.0
PARKA	110									
FACT Coherent	110					No coverage, 147-153 km due to anomalous dropout	165.5			199
FACT Semicoherent and Incoherent	110					No coverage, 161-165.5 km 100% coverage to 199 km except for 5 km interval at 150 km	163.0	176.0	176.5	199

1a. All detection ranges in kilometers.

1b. Range accuracy is ± 0.25 km.

2. FACT PL9D coherent data have been smoothed by a 2 km running average.

3. ZDC = Zonal Detection Coverage (percent the FOM greater than the propagation loss over the indicated range interval).

CONFIDENTIAL

(C) Table IIC-11a. Detection Range[1a,b] (km) as a Function of Figure of Merit (FOM) for PARKA Experimental Data and FACT PL9D Predictions. MGS (i.e., RAYMODE X's Internal) Type 6 Bottom Loss Used in FACT PL9D Model Runs. Source Depth = 500 ft., Receiver Depth = 300 ft., Frequency = 50 Hz.

Data Set	FOM (dB)	R_c[3]		First Convergence Zone: First Lobe Start	First Lobe End	Second Lobe Start	Second Lobe End	
PARKA	80			58.0	59.0	60.5	62.5	
FACT Coherent[2]	80	5.0		58.5	58.5	61.0	62.5	
FACT Semicoherent and Incoherent	80	6.0		58.5	58.5	61.0	62.5	
PARKA	85	11.0	ZDC[4] 60%, 11-23 km	55.0	59.0	59.5	64.5	
FACT Coherent	85	6.5	ZDC 40%, 6.5-22.5 km 100% coverage, 36-45 km	55.0			64.5	
FACT Semicoherent and Incoherent	85	38.5		54.0			64.5	
PARKA	90	36.5	100% coverage, 40-46.5 km	53.5				100% coverage, 53.5-71.5 km
FACT Coherent	90	10.0	ZDC 50%, 10-32.5 km. 100% coverage, 35-47.5 km	53.5			65.5	
FACT Semicoherent and Incoherent	90	66.0						
PARKA	95	74.5						
FACT Coherent	95	10.5	ZDC 15%, 10.5-33.0 km 100% coverage, 34-95 km					
FACT Semicoherent and Incoherent	95	135.0						
PARKA	100	125.0						
FACT Coherent	100	99.5	100% coverage except for two 0.5 km intervals at 14 & 24 km					100% coverage from 24.5 to >200 km except for 99.5-104.5 km
FACT Semicoherent and Incoherent	100	>200.0						
PARKA	105	144.0						
FACT Coherent	105	>200.0						
FACT Semicoherent and Incoherent	105	>200.0						

1a. All detection ranges in kilometers.

1b. Range accuracy is ± 0.25 km.

2. FACT PL9D coherent results have been smoothed by a 2 km running average.

3. R_c = Range to which coverage is continuous.

4. ZDC = Zonal Detection Coverage (percent the FOM has a greater value than the propagation loss over the indicated interval).

(C) Table IIC-11b. Detection Range[1a,b] (km) as a Function of Figure of Merit (FOM) for PARKA Experimental Data and FACT PL9D Predictions. MGS (i.e., RAYMODE X's Internal) Type 6 Bottom Loss Used in FACT PL9D Model Runs. Source Depth = 500 ft., Receiver Depth = 300 ft., Frequency = 50 Hz.

Data Set	FOM (dB)	Second Convergence Zone					Third Convergence Zone			
		First Lobe		Second Lobe			First Lobe		Second Lobe	
		Start	End	Start	End		Start	End	Start	End
PARKA	80									
FACT Coherent[2]										
FACT Semicoherent and Incoherent	80									
PARKA	85	115.5	117.5				171.0	171.0	173.0	174.5
FACT Coherent	85									
FACT Semicoherent and Incoherent	85			120.0	125.0					
PARKA	90	114.0			120.5		169.5			179.0
FACT Coherent	90	111.0			128.0		168.0	173.0	178.5	188.0
FACT Semicoherent and Incoherent	90									
PARKA	95	110.0			123.5	100% coverage, 162-167.5 km				
FACT Coherent	95									
FACT Semicoherent and Incoherent	95									
PARKA	100	112.0			125.0	100% coverage resumes at 158 km				181.5
FACT Coherent	100									
FACT Semicoherent and Incoherent	100									
PARKA	105					No coverage, 149-155 km 100% coverage, 155 to 200 km				
FACT Coherent	105									
FACT Semicoherent and Incoherent	105									

1a. All detection ranges in kilometers.

1b. Range accuracy is ± 0.25 km.

2. FACT PL9D coherent results have been smoothed by a 2 km running average.

(C) Table IIC-12a. Detection Range[1a,b] (km) as a Function of Figure of Merit (FOM) for PARKA Experimental Data and FACT PL9D Predictions. MGS (i.e., RAYMODE X's Internal) Type 6 Bottom Loss Used in FACT PL9D Model Runs. Source Depth = 500 ft., Receiver Depth = 300 ft., Frequency = 400 Hz.

Data Set	FOM (dB)	R_c [3]		First Convergence Zone: First Lobe Start	First Lobe End	Second Lobe Start	Second Lobe End	
PARKA	80							
FACT Coherent[2]	80	5.0				62.0	62.0	
FACT Semicoherent and Incoherent	80	5.0		58.0			63.0	
PARKA	85	9.0		58.0			59.5	
FACT Coherent	85	6.5		56.0			64.0	
FACT Semicoherent and Incoherent	85	7.0		56.0			64.0	
PARKA	90	36.5		55.5			59.0	
FACT Coherent	90	7.5		56.0			63.0	
FACT Semicoherent and Incoherent	90	9.0		55.5			65.0	
PARKA	95	50.0		54.0			66.0	
FACT Coherent	95	12.0	No coverage 12-54.5 km except for 17.5-21 km	54.5			67.0	
FACT Semicoherent and Incoherent	95	32.5		55.0			68.0	
PARKA	100	69.0					69.0	ZDC 15%, 69-108 km
FACT Coherent	100	13.0	ZDC[4] 35%, 13-54 km	54.0			70.5	
FACT Semicoherent and Incoherent	100	71.0		54.0			70.5	
PARKA	105	129.0						
FACT Coherent	105	14.0	ZDC 90%, 14-55 km 100% coverage, 49.5-72.5 km				72.5	
FACT Semicoherent and Incoherent	105	73.0					73.0	
PARKA	110	188.0						
FACT Coherent	110	73.5						No coverage 73.5-111 km except 93-95 km
FACT Semicoherent and Incoherent	110	74.0					74.0	
PARKA	115	>200.0						
FACT Coherent	115	74.0						ZDC 15%, 74-110.5 km
FACT Semicoherent and Incoherent	115	138.5						
PARKA	120							
FACT Coherent	120	78.5						ZDC 50%, 78.5-101.5 km 100% coverage, 101.5-140 km
FACT Semicoherent and Incoherent	120	139.0						

1a. All detection ranges in kilometers.

1b. Range accuracy is ± 0.25 km.

2. FACT PL9D coherent data have been smoothed by a 2 km running average.

3. R_c - Range to which coverage is continuous

4. ZDC = Zonal Detection Coverage **(percent the FOM is greater than the propagation loss over the indicated range interval).**

(C) Table IIC-12b. Detection Range[1a,b] (km) as a Function of Figure of Merit (FOM) for PARKA Experimental Data and FACT PL9D Predictions. MGS (i.e., RAYMODE X's Interval) Type 6 Bottom Loss Used in FACT PL9D Model Runs. Source Depth = 500 ft., Receiver Depth = 300 ft., Frequency = 400 Hz.

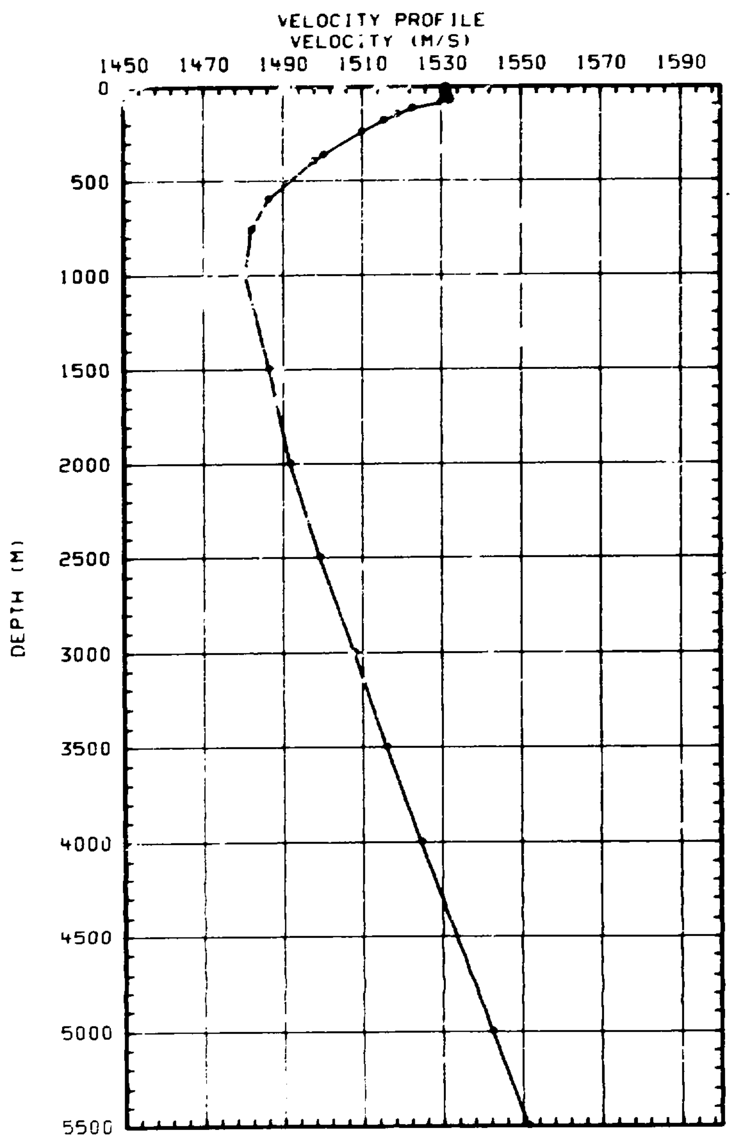
Data Set	FOM (dB)	Second Convergence Zone					Third Convergence Zone			
		First Lobe		Second Lobe			First Lobe		Second Lobe	
		Start	End	Start	End		Start	End	Start	End
PARKA	90	114.5			120.0					
FACT Coherent[2]	90	113.0			126.0		171.0	173.0	181.5	185.0
FACT Semicoherent and Incoherent	90	113.0			126.0		171.0	173.0	181.5	185.0
PARKA	95	110.5			127.0					
FACT Coherent	95									
FACT Semicoherent and Incoherent	95									
PARKA	100	108.0			128.0	3 km coverage at 168 km				
FACT Coherent	100	112.0			128.0		169.0	174.0	178.5	189.0
FACT Semicoherent and Incoherent	100	112.0			127.5		169.0	174.0	178.5	189.0
PARKA	105				129.0	ZDC[3] 60%, 129-183 km No coverage past 183 km				
FACT Coherent	105	111.0			134.0		167.0	175.0	177.0	195.0
FACT Semicoherent and Incoherent	105	111.0			134.0		167.0	175.0	177.0	195.0
PARKA	110									
FACT Coherent	110	110.5			137.0		166.5	176.0	176.0	198.5
FACT Semicoherent and Incoherent	110	110.0			137.0		166.5	176.0	177.0	198.5
PARKA	115									
FACT Coherent	115	109.5			138.5		166.0			>200
FACT Semicoherent and Incoherent	115				138.5		166.0	176.0	176.5	>200
PARKA	120									
FACT Coherent	120				140.0		165.0			>200
FACT Semicoherent and Incoherent	120				139.0		165.0	176.0	176.5	>200

1a. All detection ranges in kilometers.

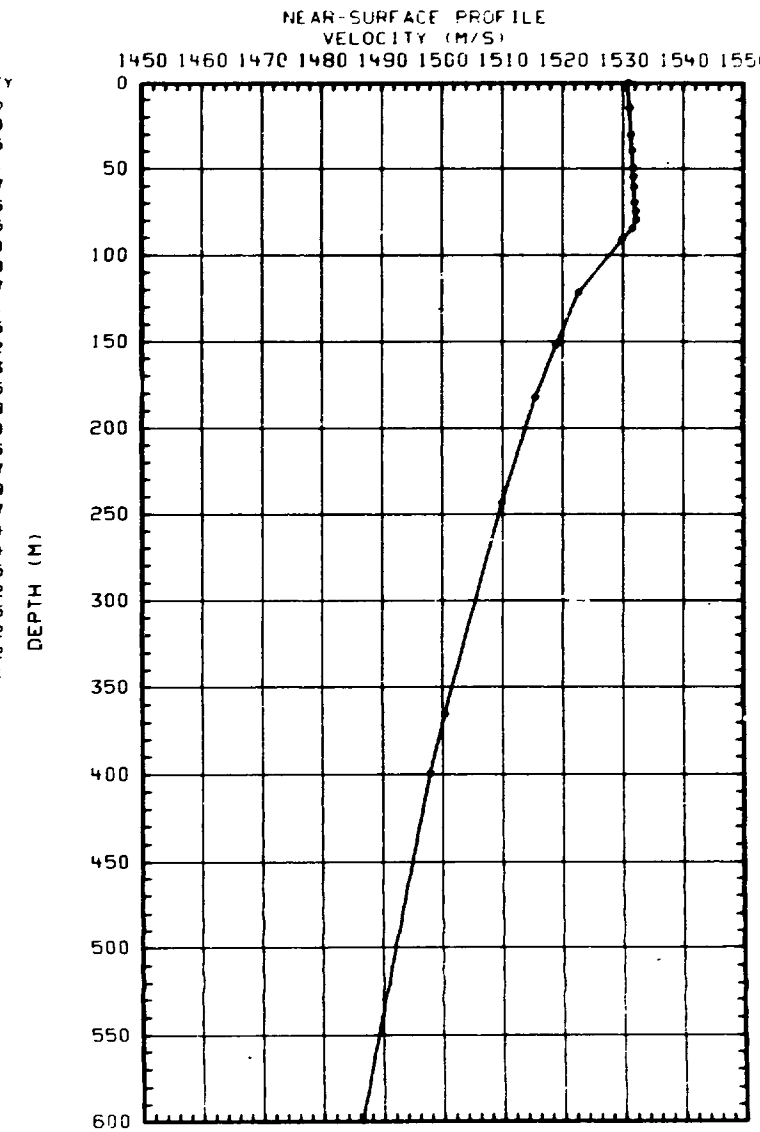
1b. Range accuracy is ± 0.25 km.

2. FACT PL9D coherent results have been smoothed by a 2 km running average.

3. ZDC = Zonal Detection Coverage (percent for which the FOM is greater than the propagation loss over the indicated range interval).

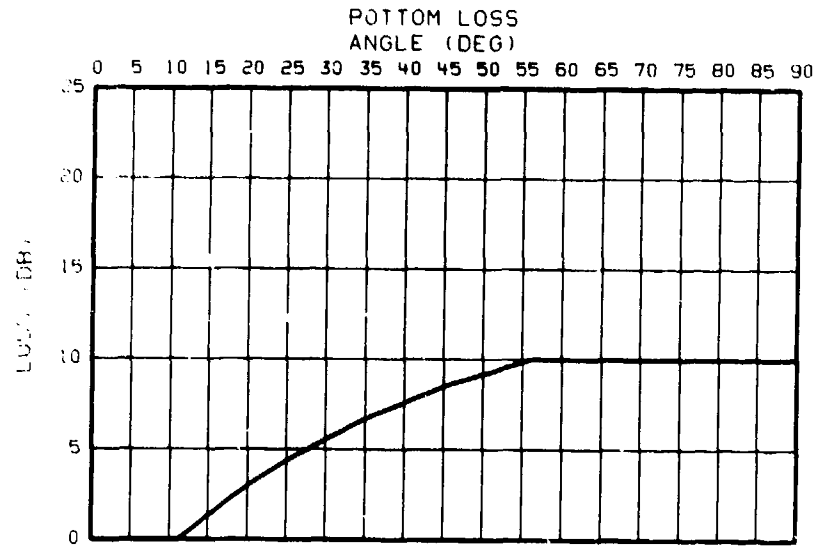


DEPTH	VELOCITY
0.0	1530.75
15.2	1531.00
30.5	1531.25
40.0	1531.41
50.0	1531.57
55.0	1531.66
61.0	1531.75
70.0	1531.90
75.0	1531.98
80.0	1532.07
85.0	1531.41
91.4	1529.75
121.9	1522.52
152.4	1518.83
182.8	1515.35
243.8	1509.78
365.7	1500.30
400.0	1497.76
600.0	1486.27
762.0	1481.89
1000.0	1480.47
1500.0	1486.44
2000.0	1491.74
2500.0	1499.15
3000.0	1507.92
3500.0	1515.95
4000.0	1524.62
5000.0	1542.32
5500.0	1551.31



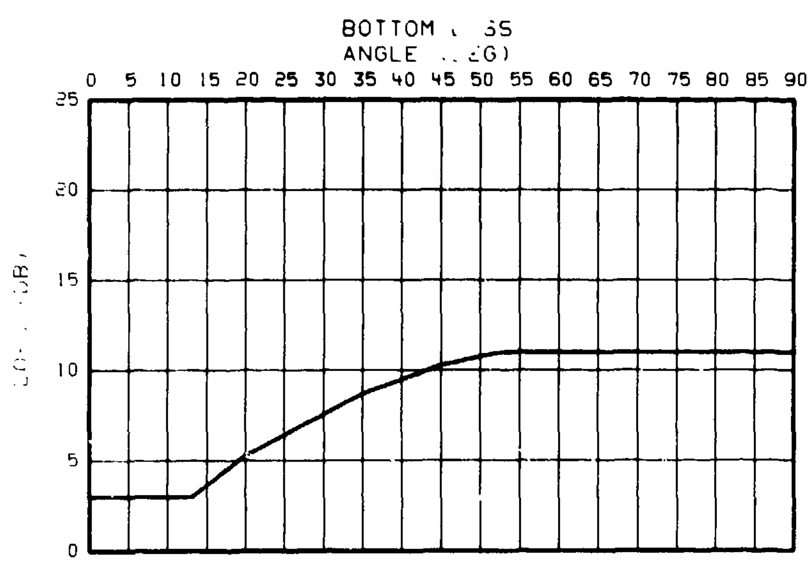
CONFIDENTIAL

(U) Figure IIC-1. KAYMODE X, PARKA Profile, Bottom Loss = MGS 6, 400 Hertz



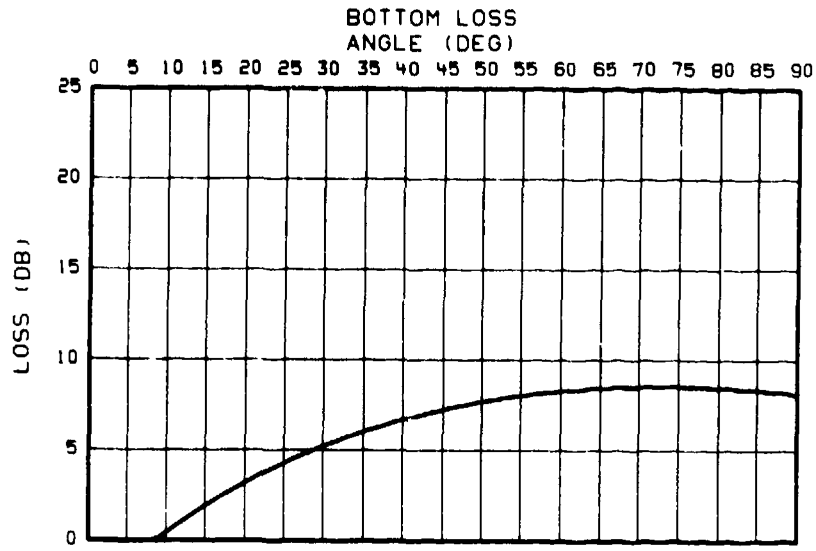
CONFIDENTIAL

(C) Figure IIC-2. Bottom Loss Versus Grazing Angle, FNOC 3, Frequency = 50 Hertz



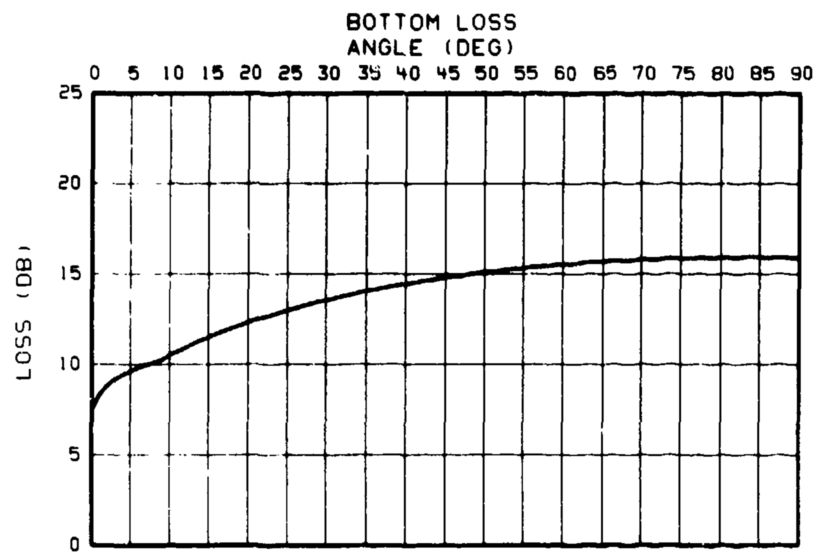
CONFIDENTIAL

(C) Figure IIC-3. Bottom Loss Versus Grazing Angle, FNOC 3, Frequency = 400 Hertz



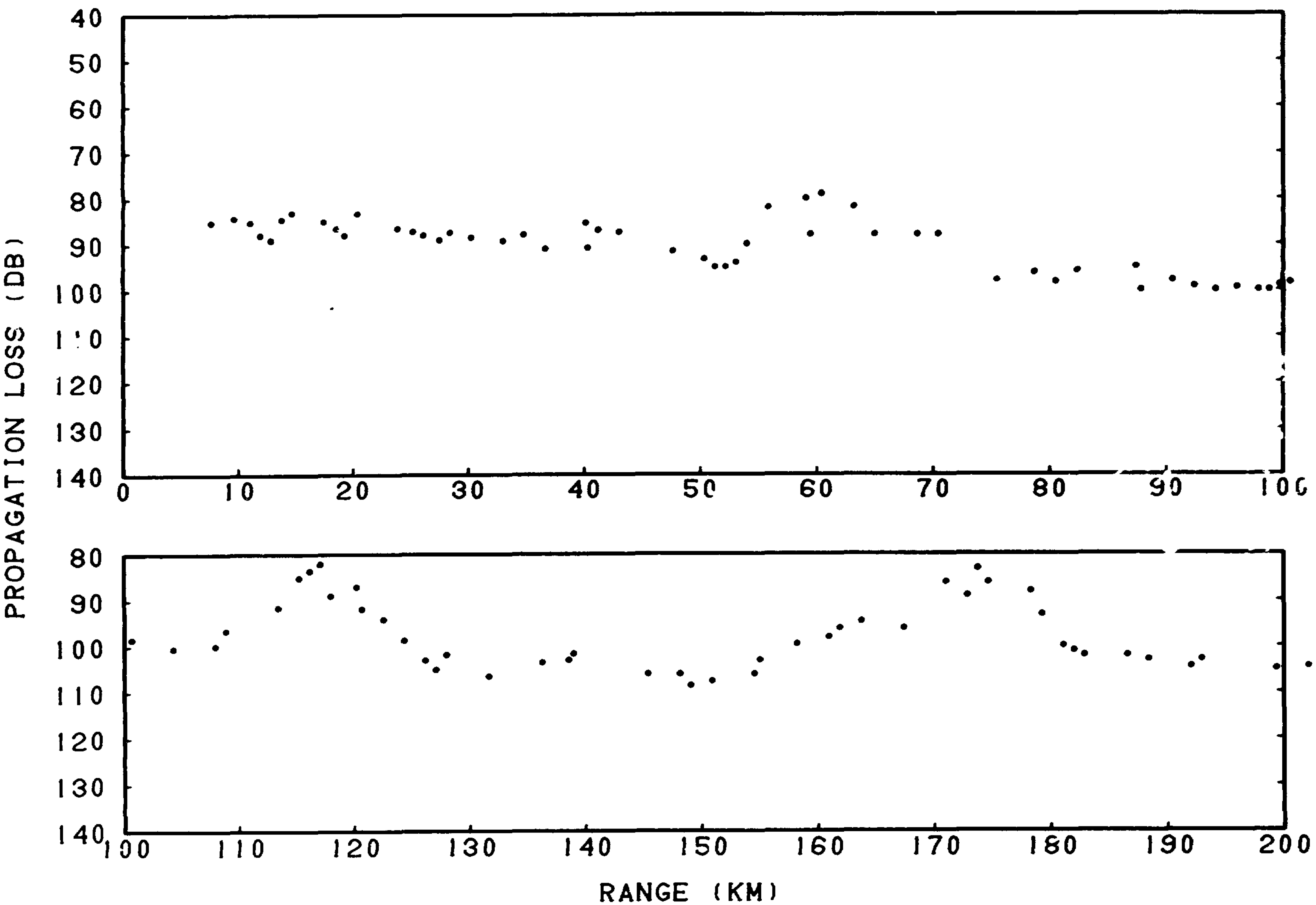
CONFIDENTIAL

(C) Figure IIC-4. Bottom Loss Versus Grazing Angle, MGS 6, Frequency = 50 Hertz



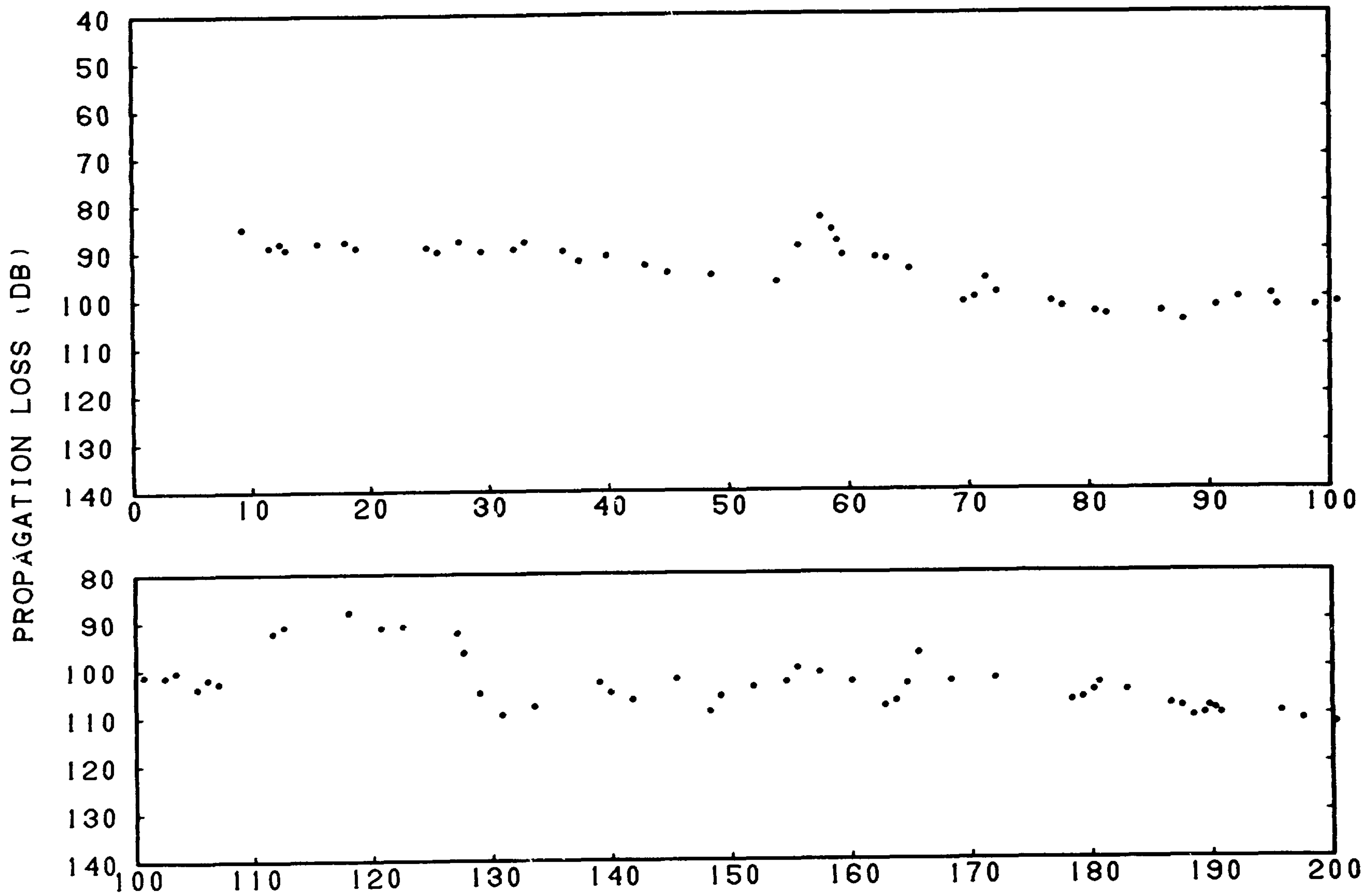
CONFIDENTIAL

(C) Figure IIC-5. Bottom Loss Versus Grazing Angle, MGS 6, Frequency = 400 Hertz



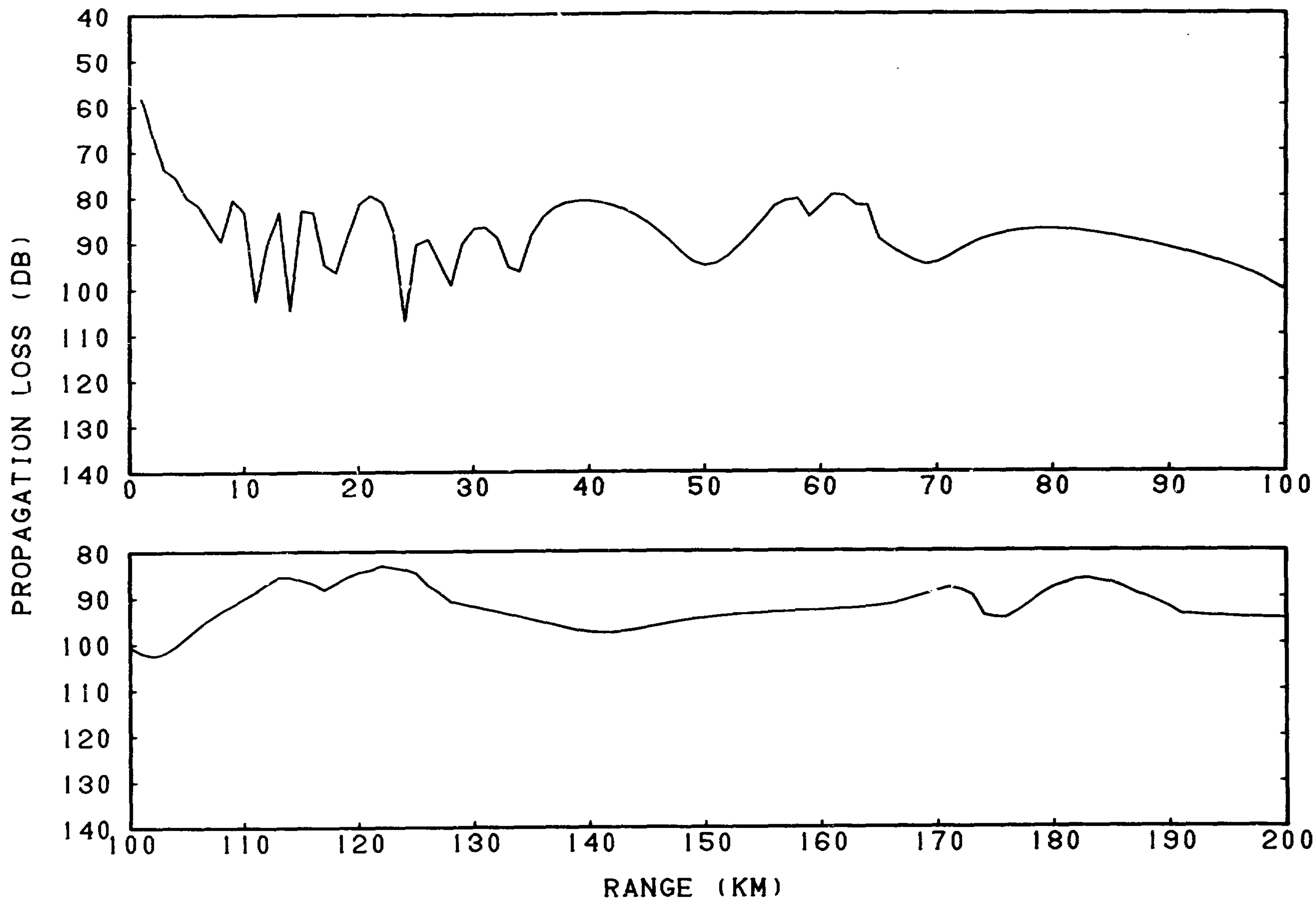
CONFIDENTIAL

(C) Figure IIC-6. PARKA Data, Source Depth = 500 Feet, Receiver Depth = 300 Feet, Frequency = 50 Hertz



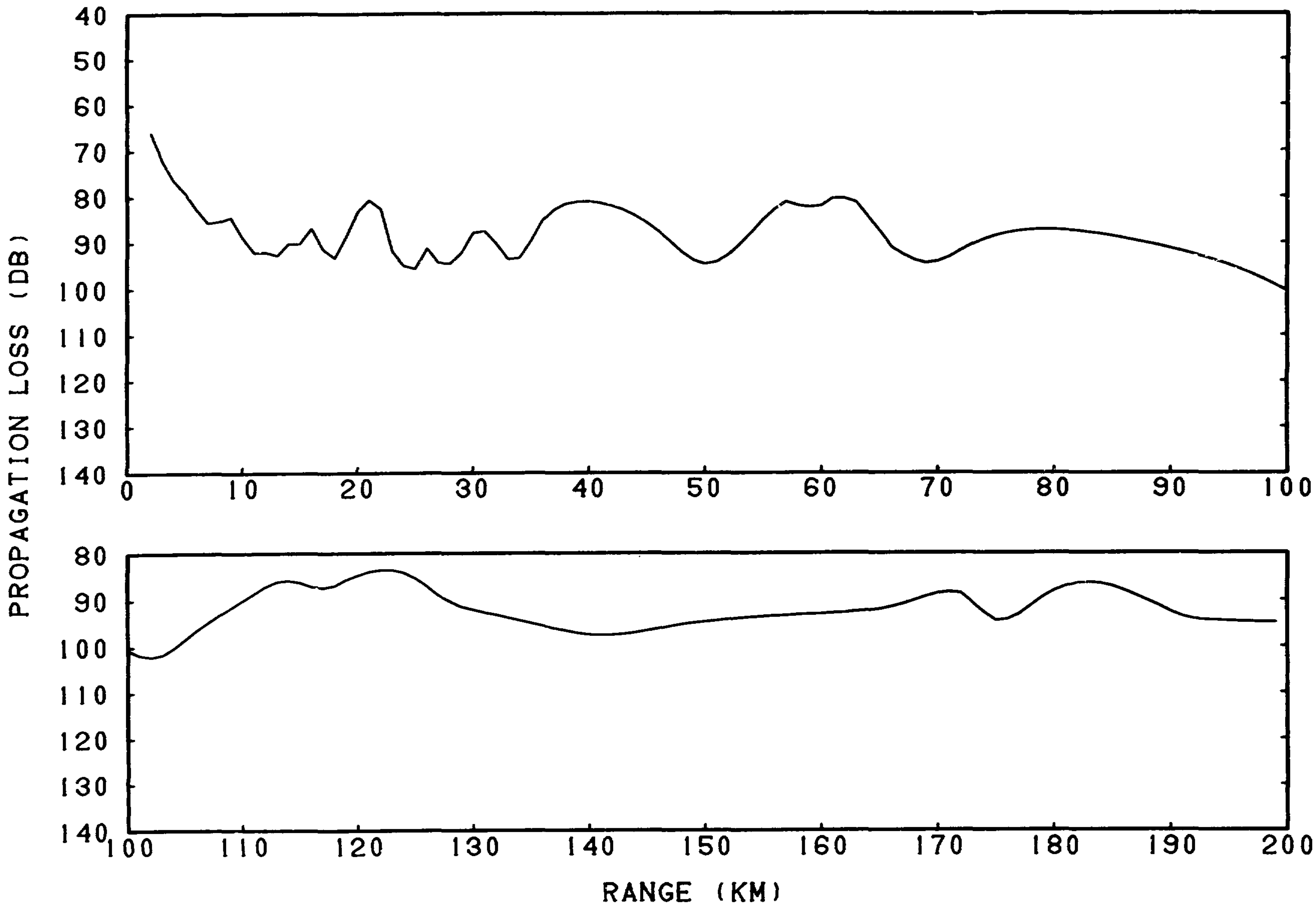
CONFIDENTIAL

(C) Figure IIC-7. PARKA Data, Source Depth = 500 Feet, Receiver Depth = 300 Feet, Frequency = 400 Hertz



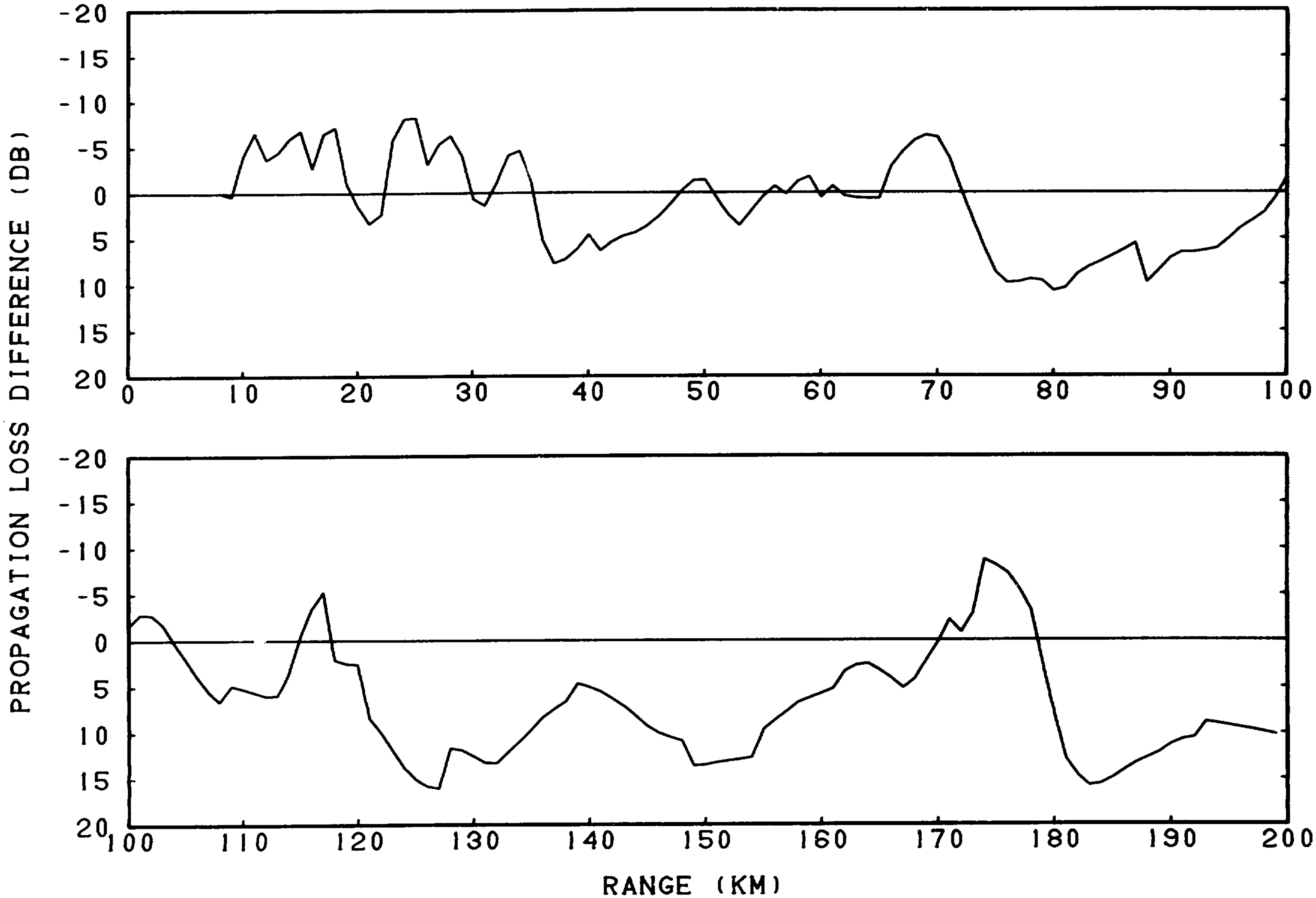
CONFIDENTIAL

(C) Figure IIC-8. FACT (Coherent) Bottom Loss = FNOC Type 3, Frequency = 50 Hertz



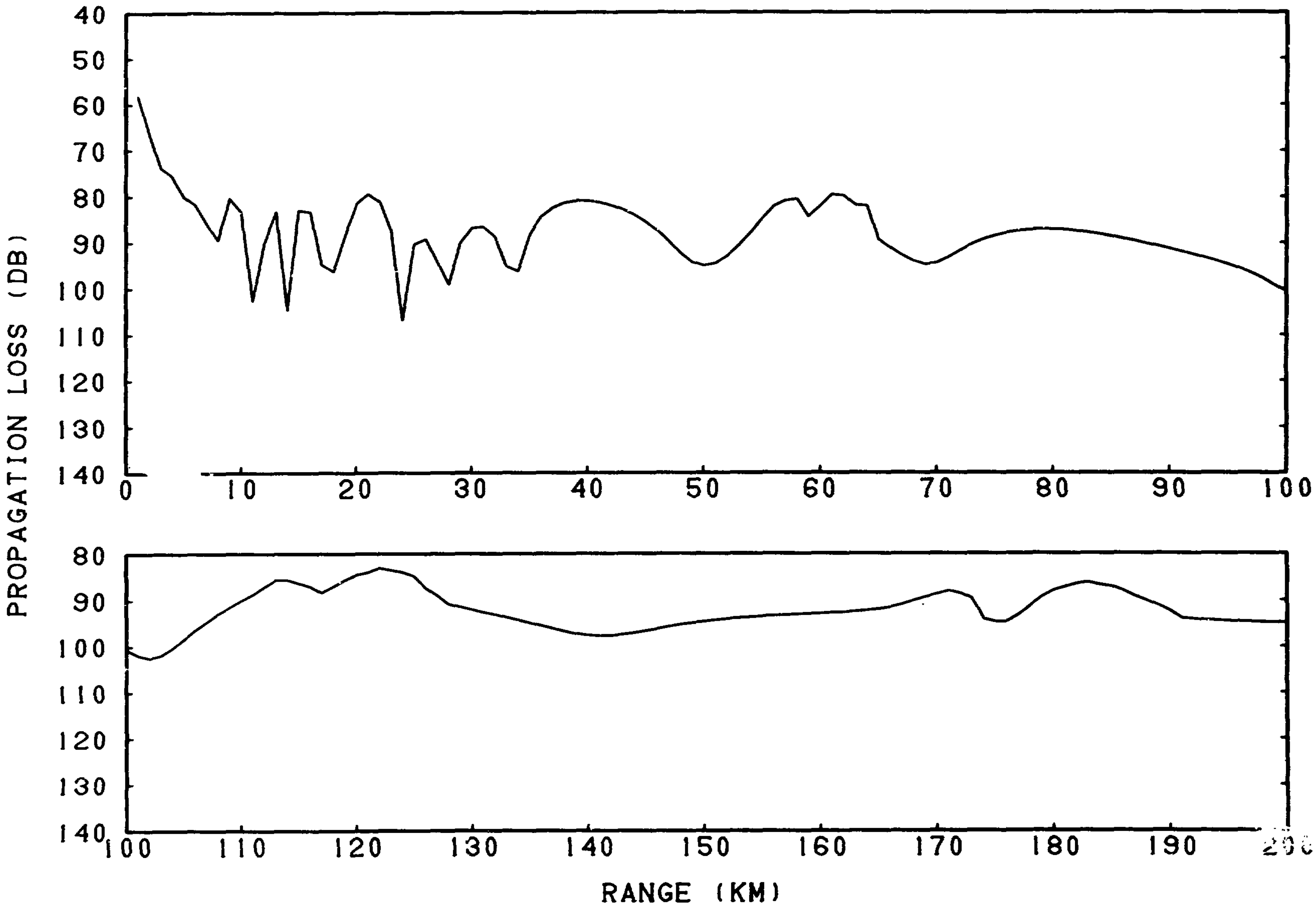
CONFIDENTIAL

(C) Figure IIC-9. FACT (Coherent) Bottom Loss = FNOC Type 3, Frequency = 50 Hertz, Sliding Averages of 3 Points (2.00 Kilometers)



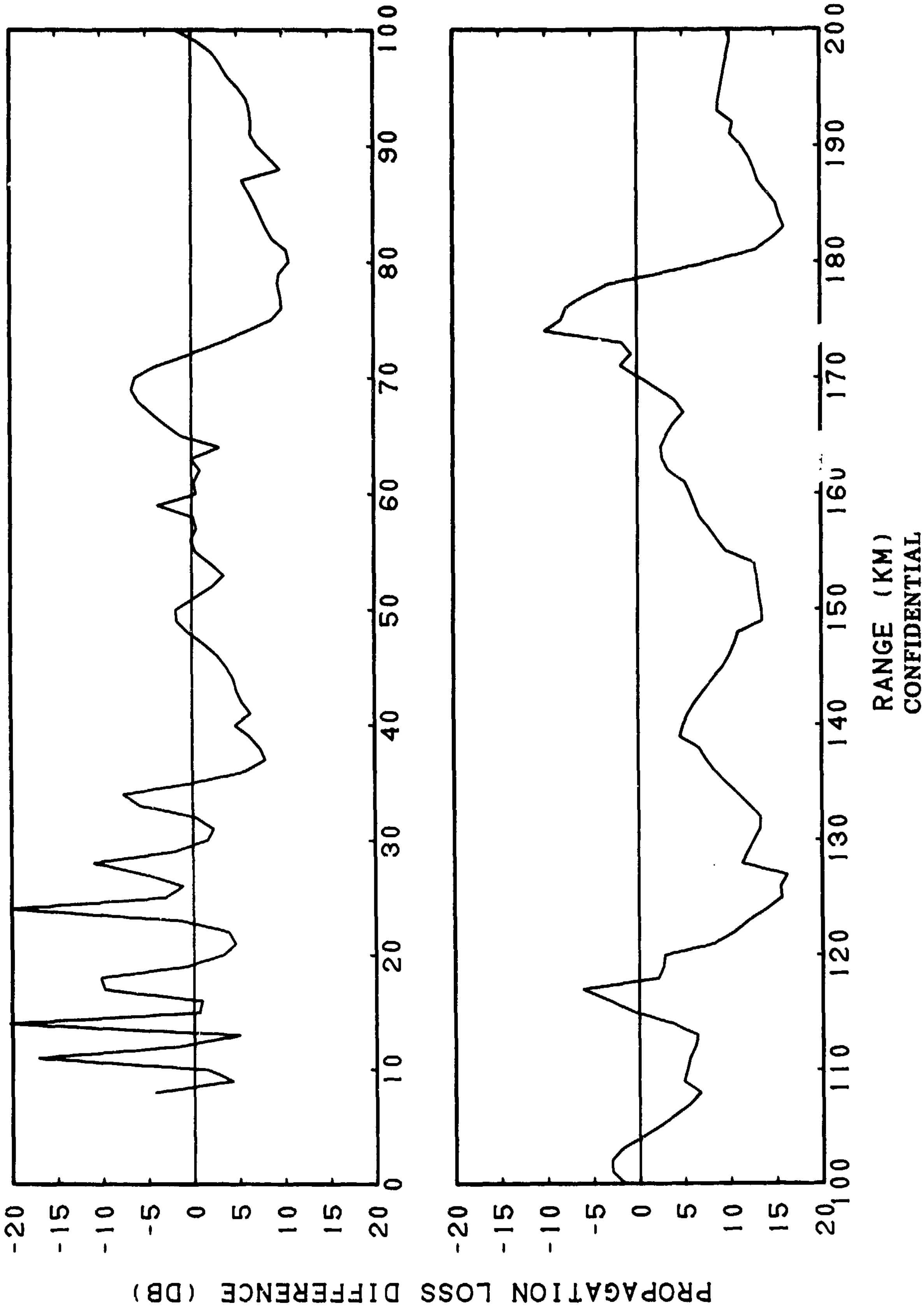
CONFIDENTIAL

(C) Figure IIC-10. Smoothed FACT (Coherent) Bottom Loss = FNOC Type 3, Frequency = 50 Hertz, Subtracted from PARKA Data, Source Depth = 500 Feet, Receiver Depth = 300 Feet, Frequency = 50 Hertz

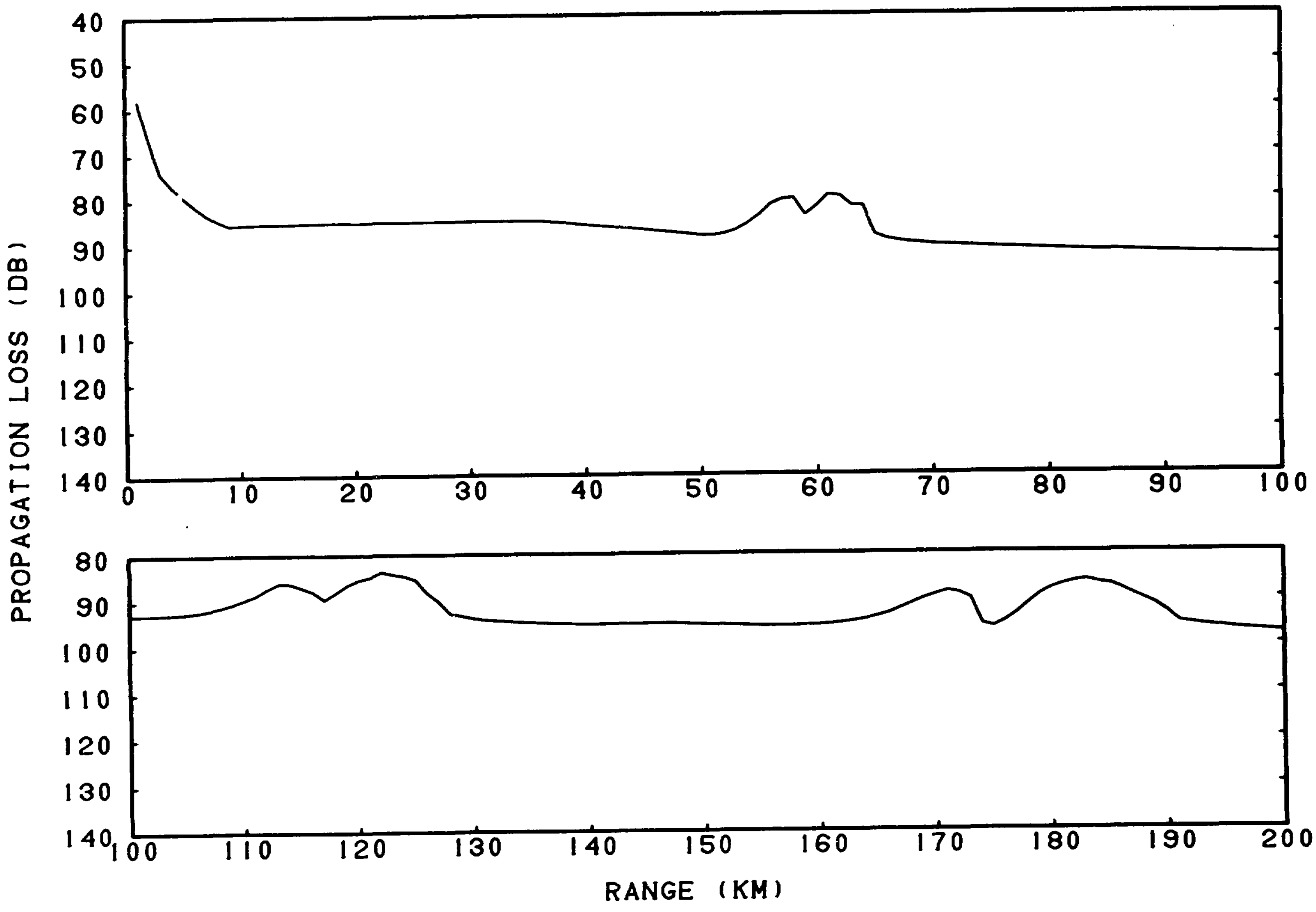


CONFIDENTIAL

(C) Figure IIC-11. FACT (Semi-coherent) Bottom Loss = FNOC Type 3, Frequency = 50 Hertz

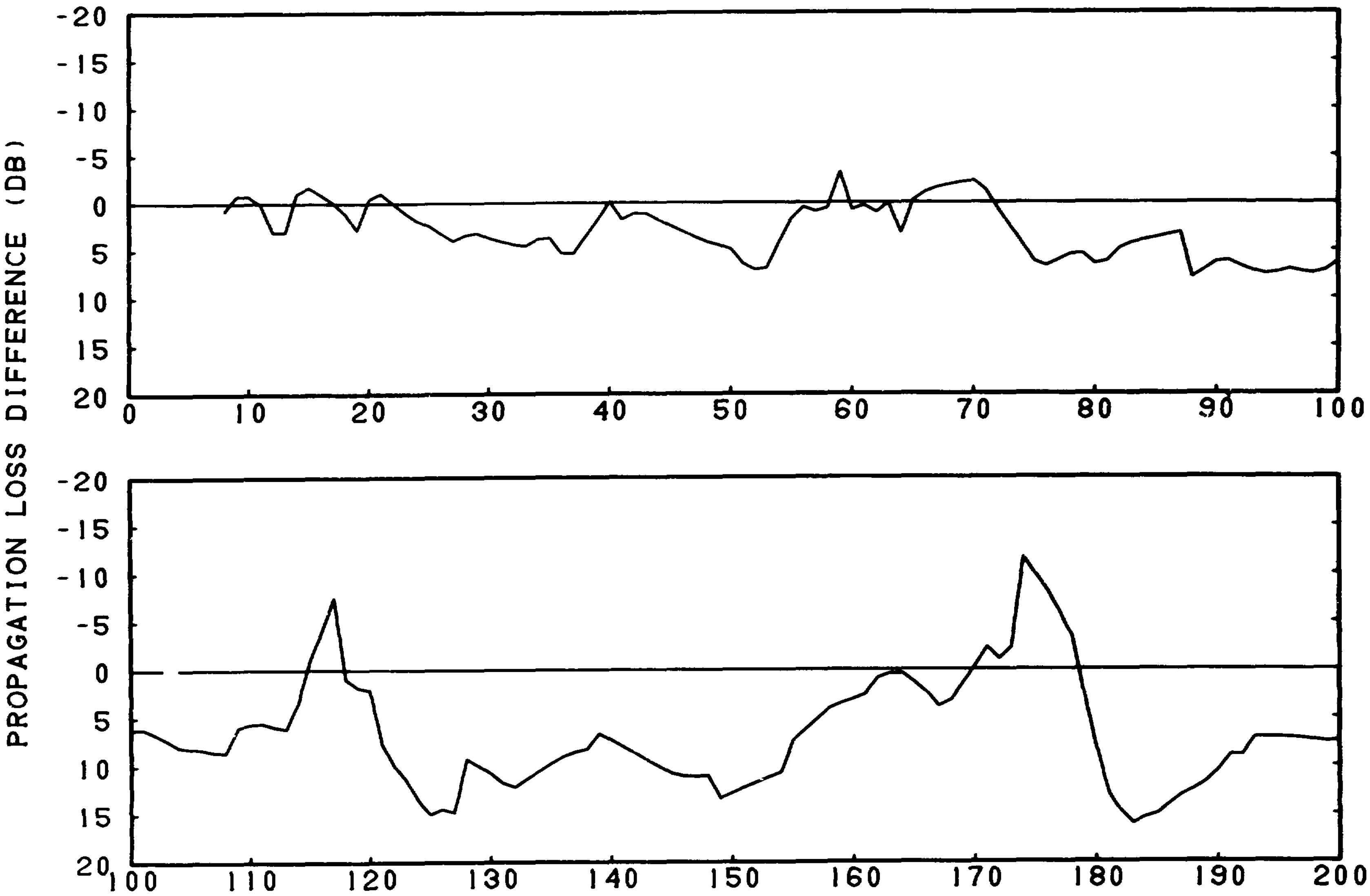


(C) Figure IIC-12. FACT (Semi-coherent) Bottom Loss = FNOC Type 3, Frequency = 50 Hertz, Subtracted from PARKA Data, Source Depth = 500 Feet, Receiver Depth = 300 Feet, Frequency = 50 Hertz



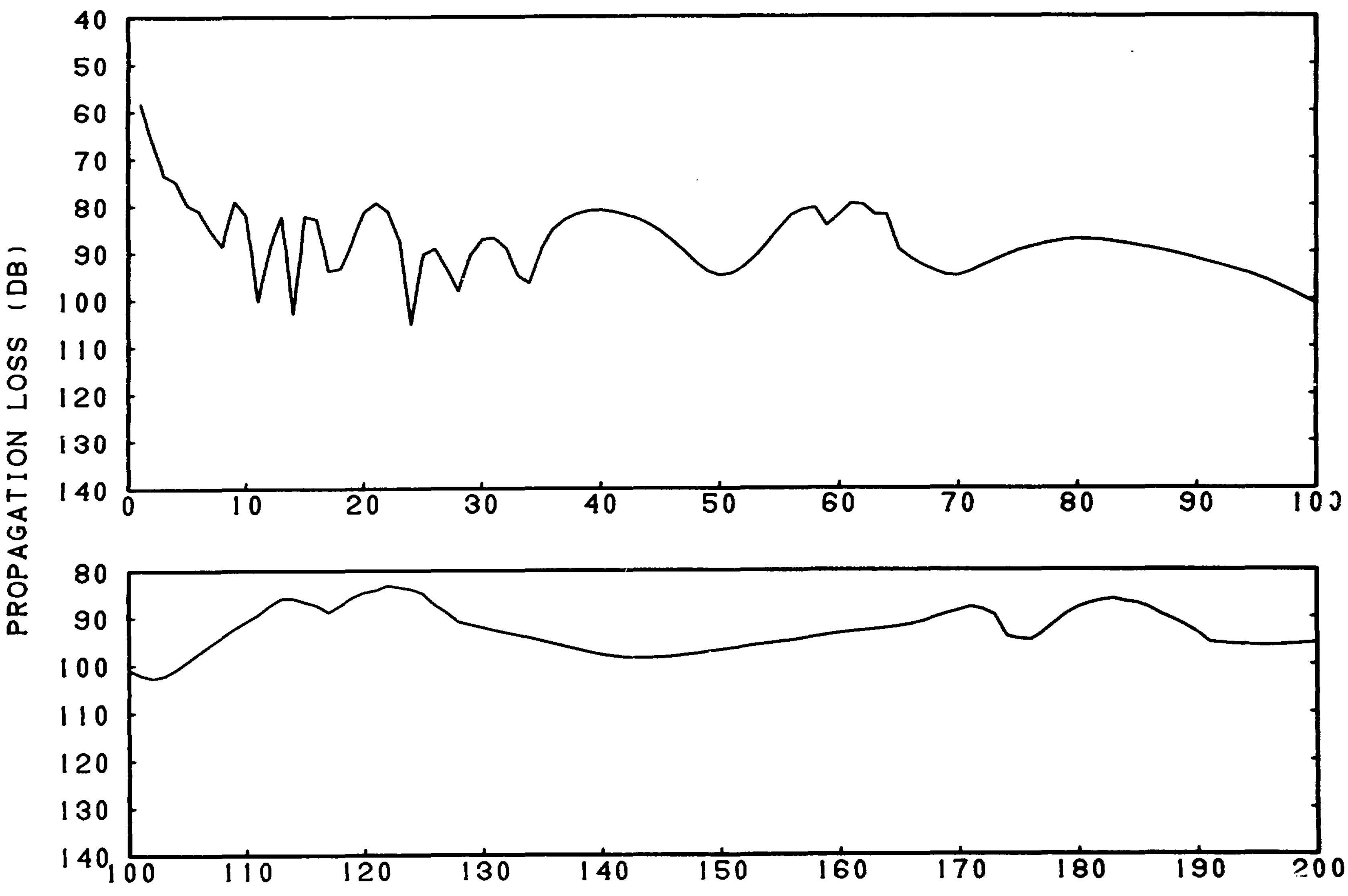
CONFIDENTIAL

(C) Figure IIC-13. FACT (Incoherent) Bottom Loss = FNOC Type 3, Frequency = 50 Hertz



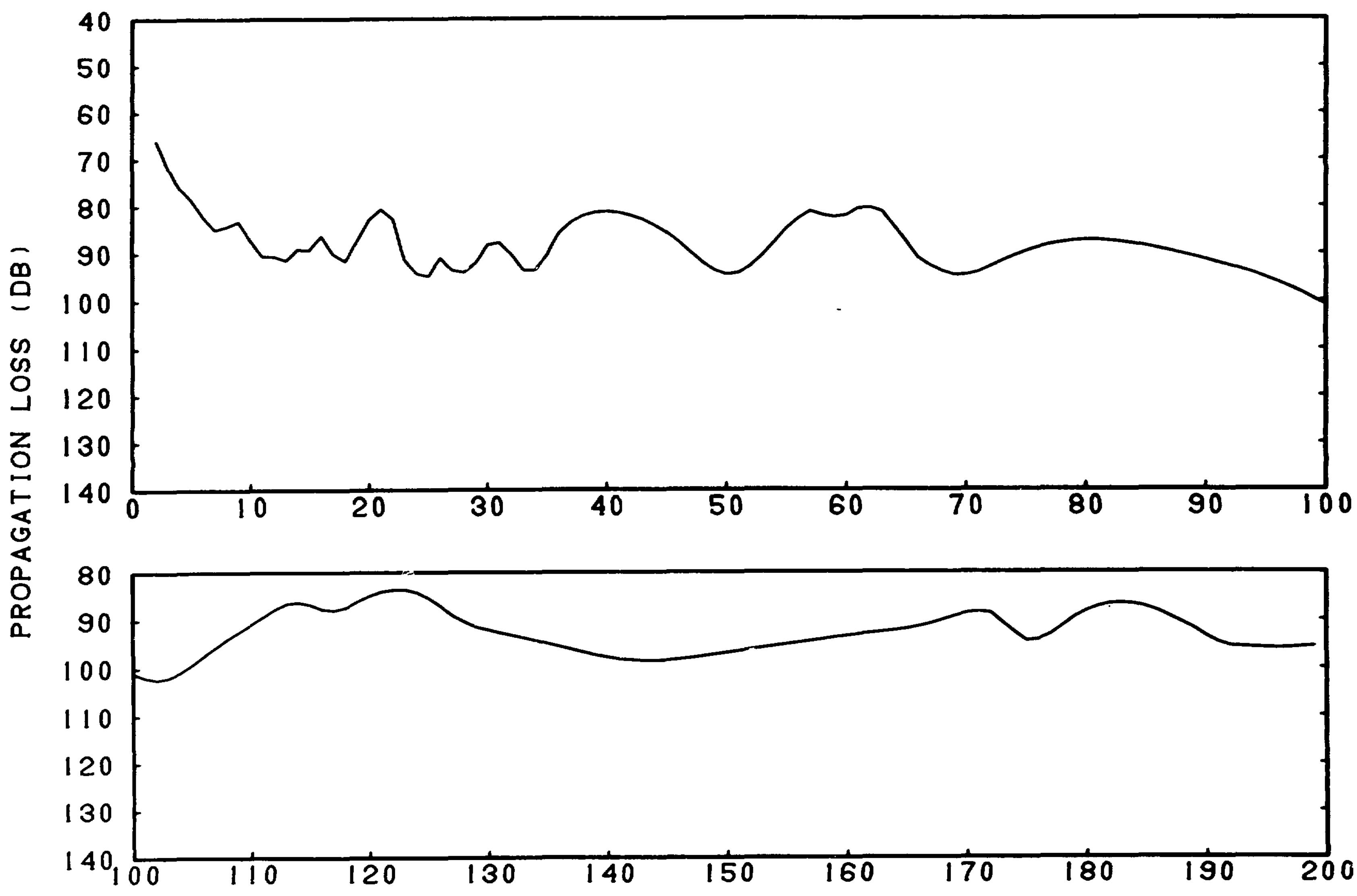
CONFIDENTIAL

(C) Figure IIC-14. FACT (Incoherent) Bottom Loss = FNOC Type 3, Frequency = 50 Hertz, Subtracted from PARKA Data, Source Depth = 500 Feet, Receiver Depth = 300 Feet, Frequency = 50 Hertz



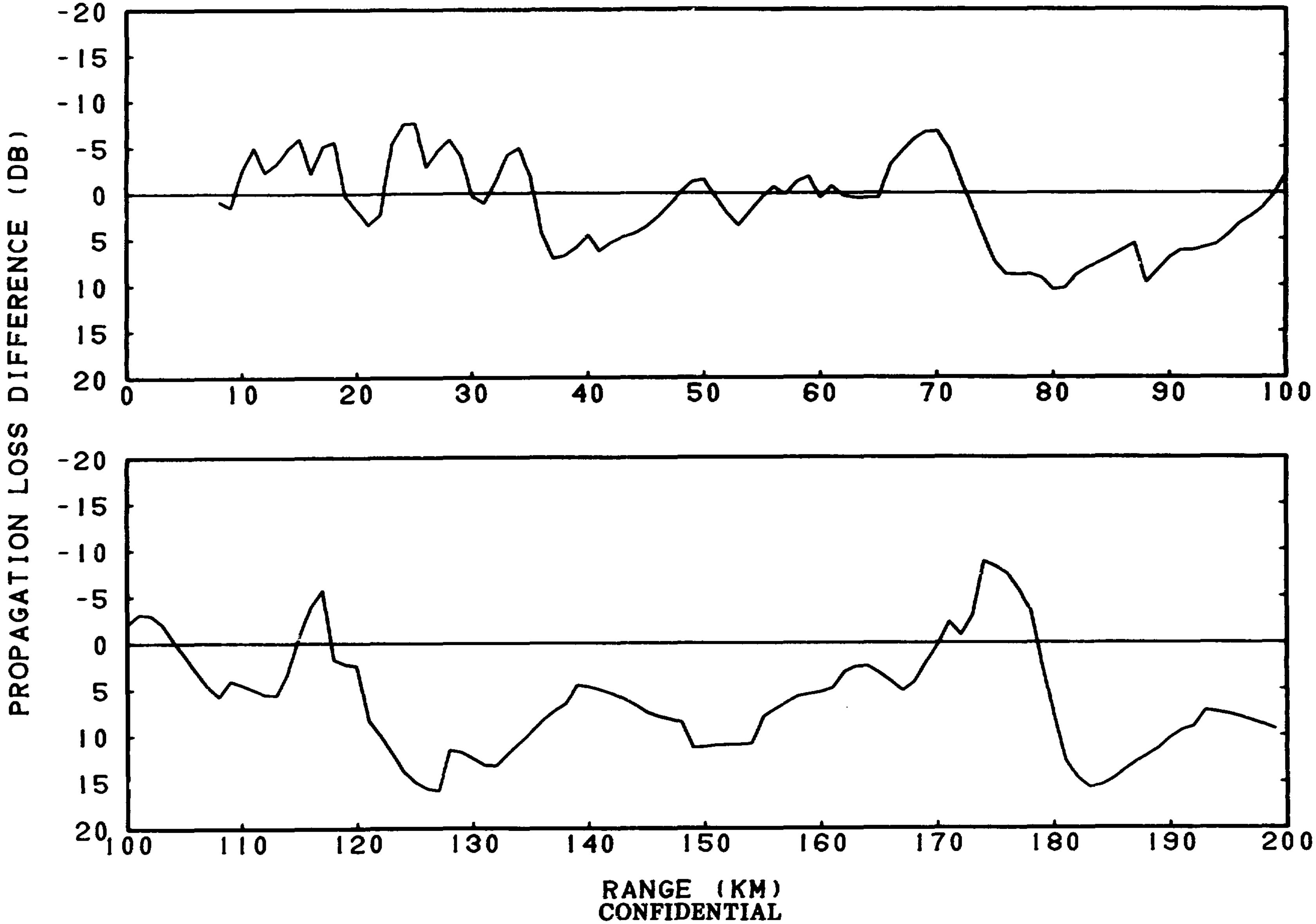
CONFIDENTIAL

(C) Figure IIC-15. FACT (Coherent) Bottom Loss = MGS 6, Frequency = 50 Hertz

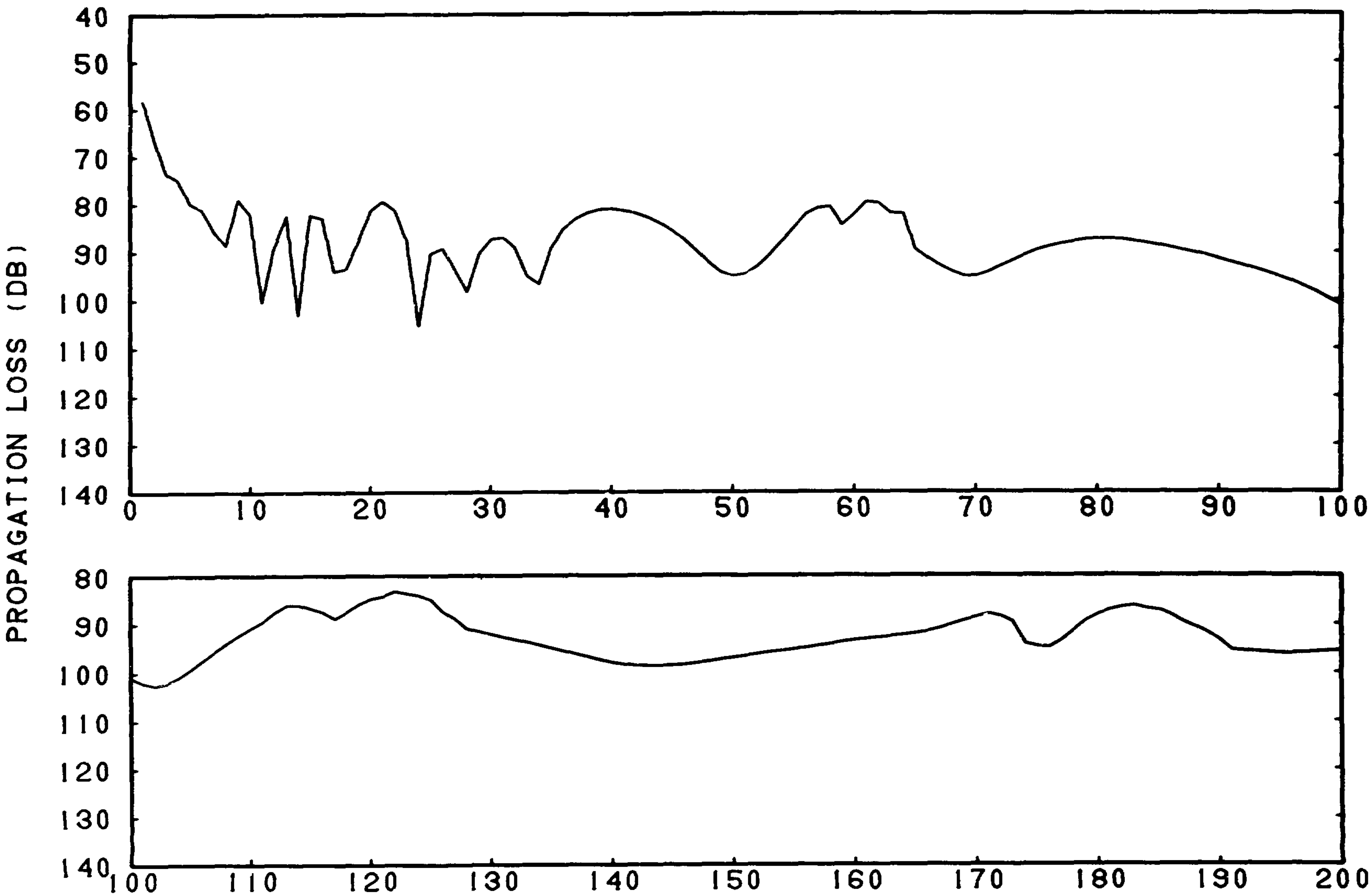


CONFIDENTIAL

(C) Figure IIC-16. FACT (Coherent) Bottom Loss = MGS 6, Frequency = 50 Hertz, Sliding Averages of 3 Points (2.00 Kilometers)

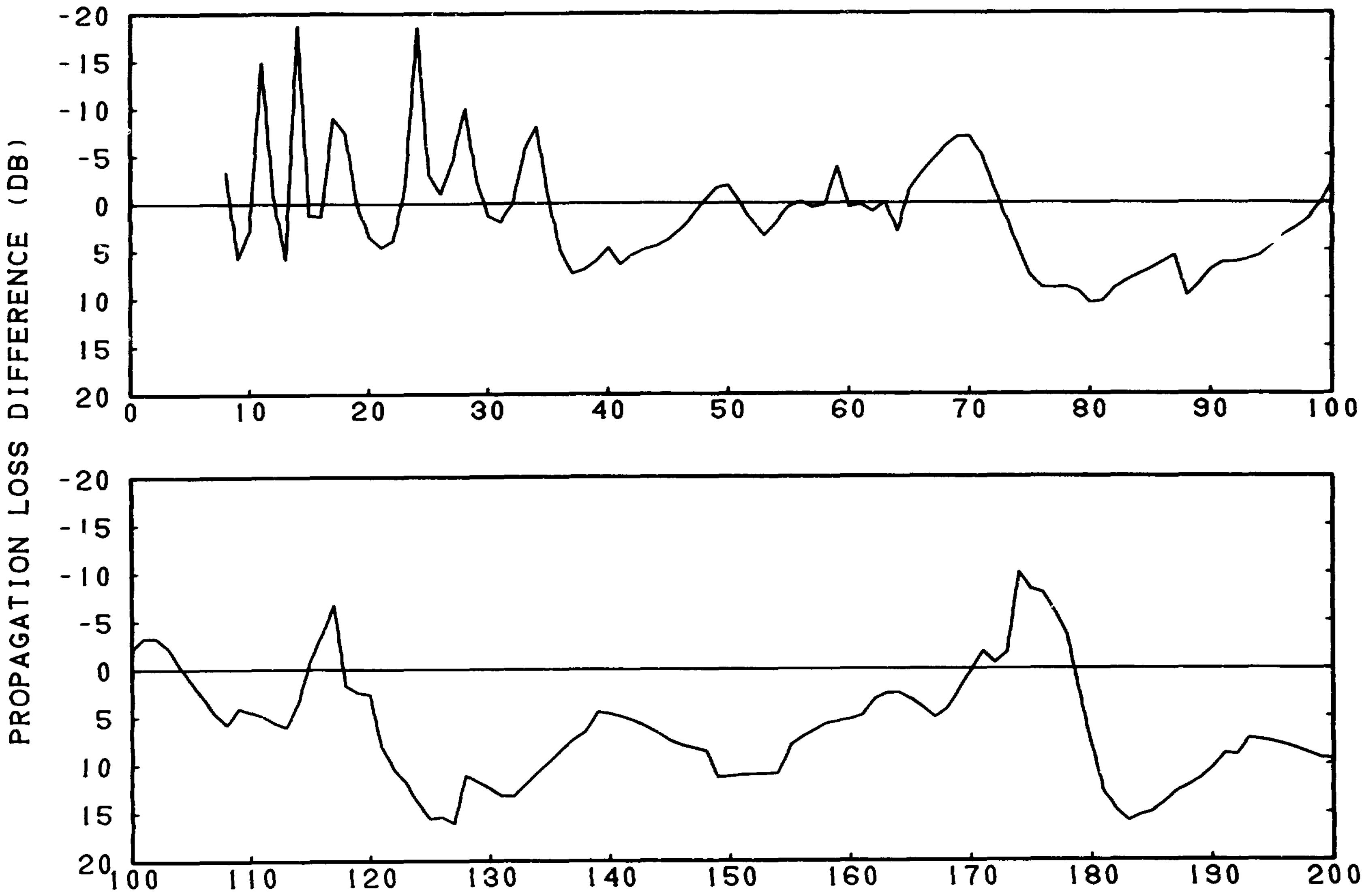


(C) Figure IIC-17. Smoothed FACT (Coherent) Bottom Loss = MGS 6, Frequency = 50 Hertz, Subtracted from PARKA Data, Source Depth = 500 Feet, Receiver Depth = 300 Feet, Frequency = 50 Hertz



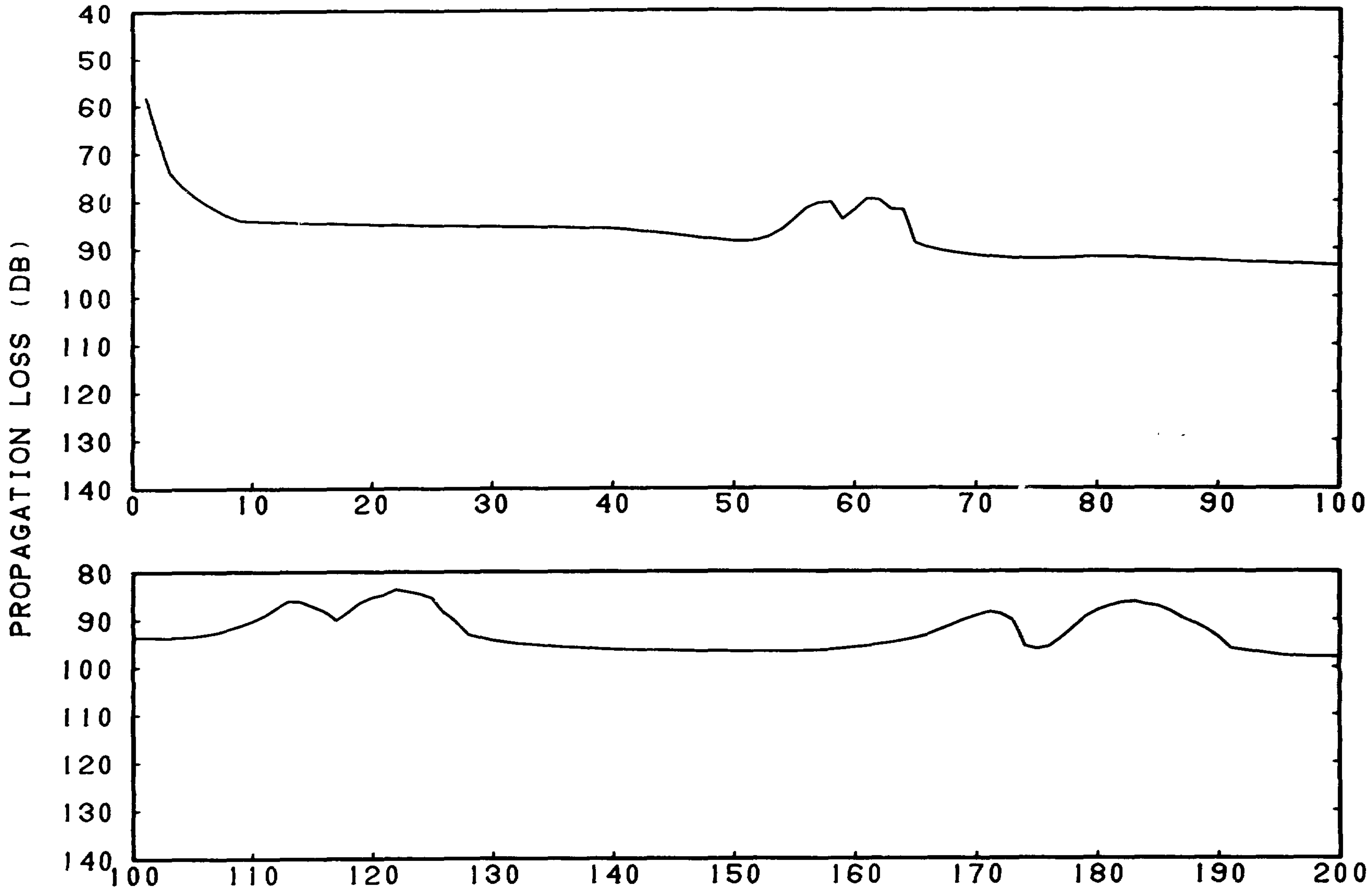
CONFIDENTIAL

(C) Figure IIC-18. FACT (Semi-coherent) Bottom Loss = MCS 6, Frequency = 50 Hertz



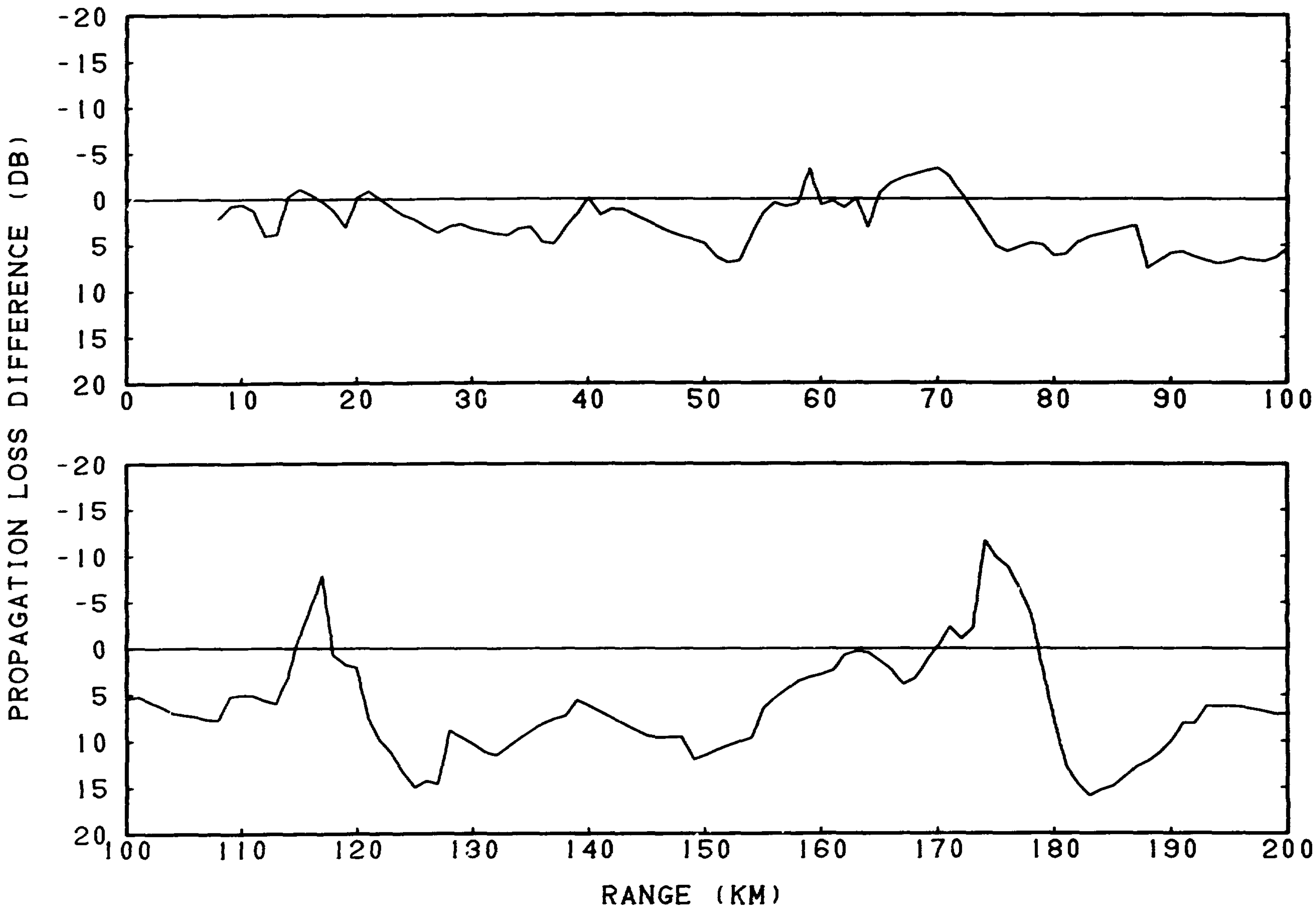
CONFIDENTIAL

(C) Figure IIC-19. FACT (Semi-coherent) Bottom Loss = MGS 6, Frequency = 50 Hertz, Subtracted from PARKA Data, Source Depth = 500 Feet, Receiver Depth = 300 Feet, Frequency = 50 Hertz



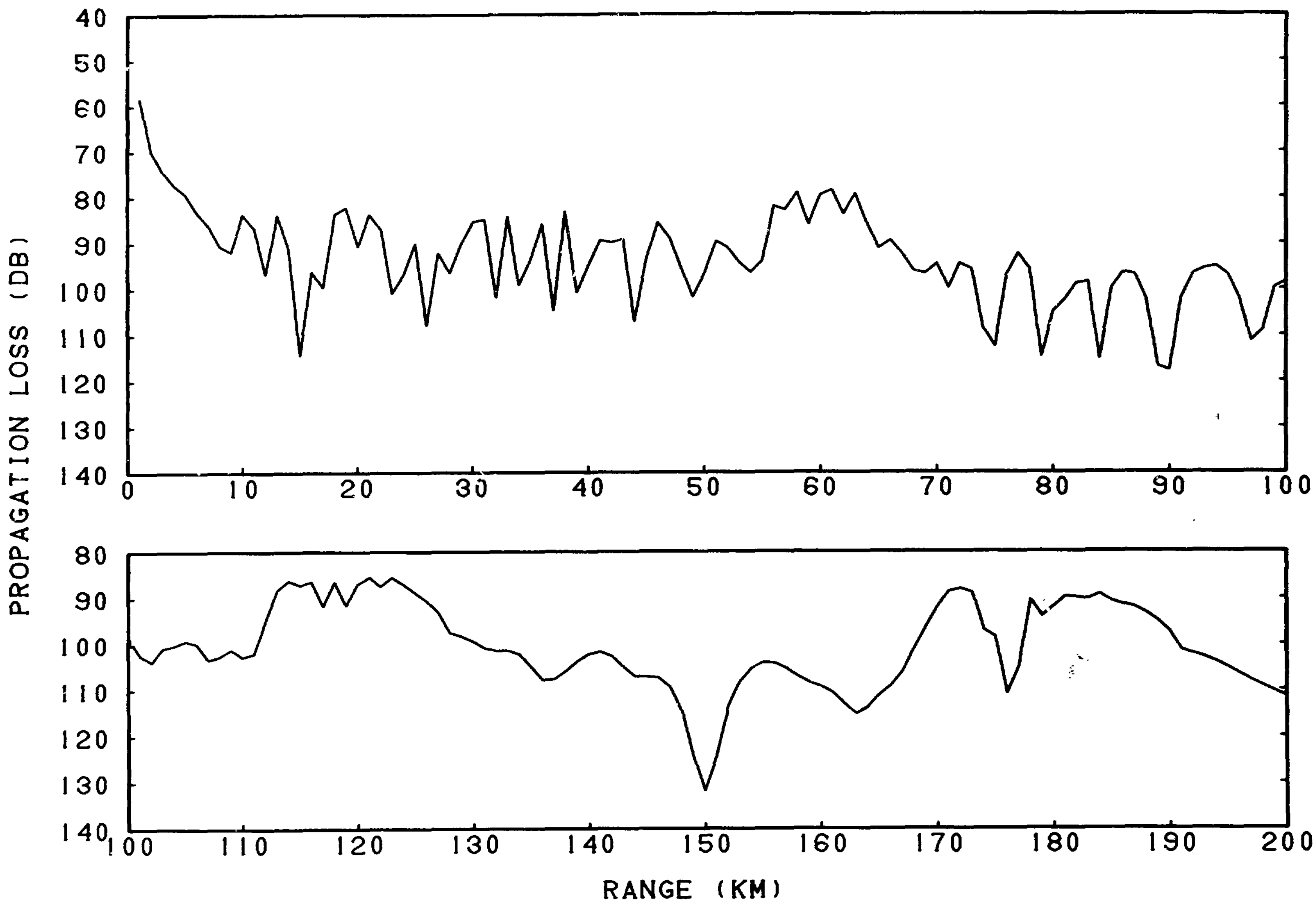
CONFIDENTIAL

(C) Figure IIC-20. FACT (Incoherent) Bottom Loss = MGS 6, Frequency = 50 Hertz



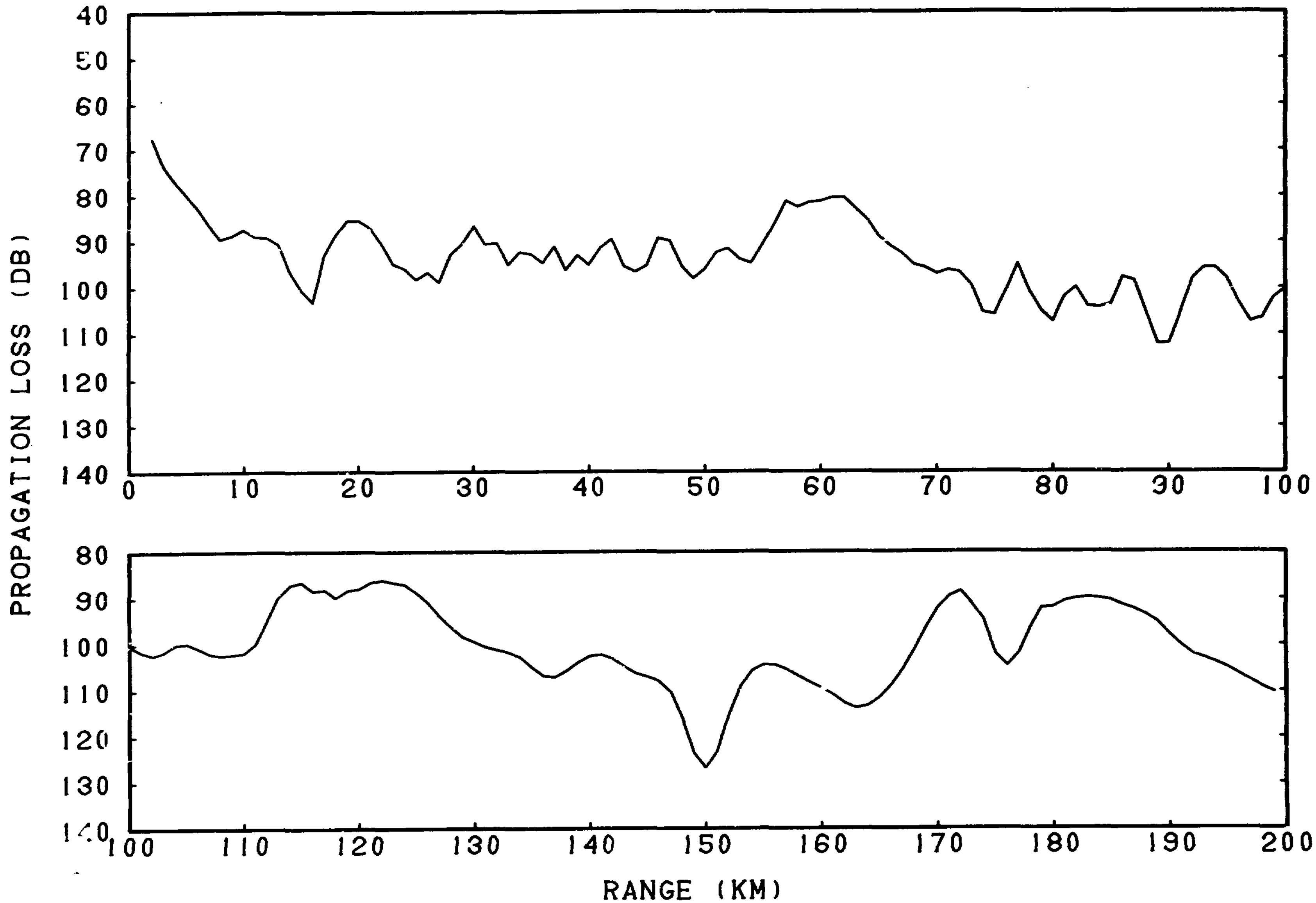
CONFIDENTIAL

(C) Figure IIC-21. FACT (Incoherent) Bottom Loss = MGS 6, Frequency = 50 Hertz, Subtracted from PARKA Data, Source Depth = 500 Feet, Receiver Depth = 300 Feet, Frequency = 50 Hertz



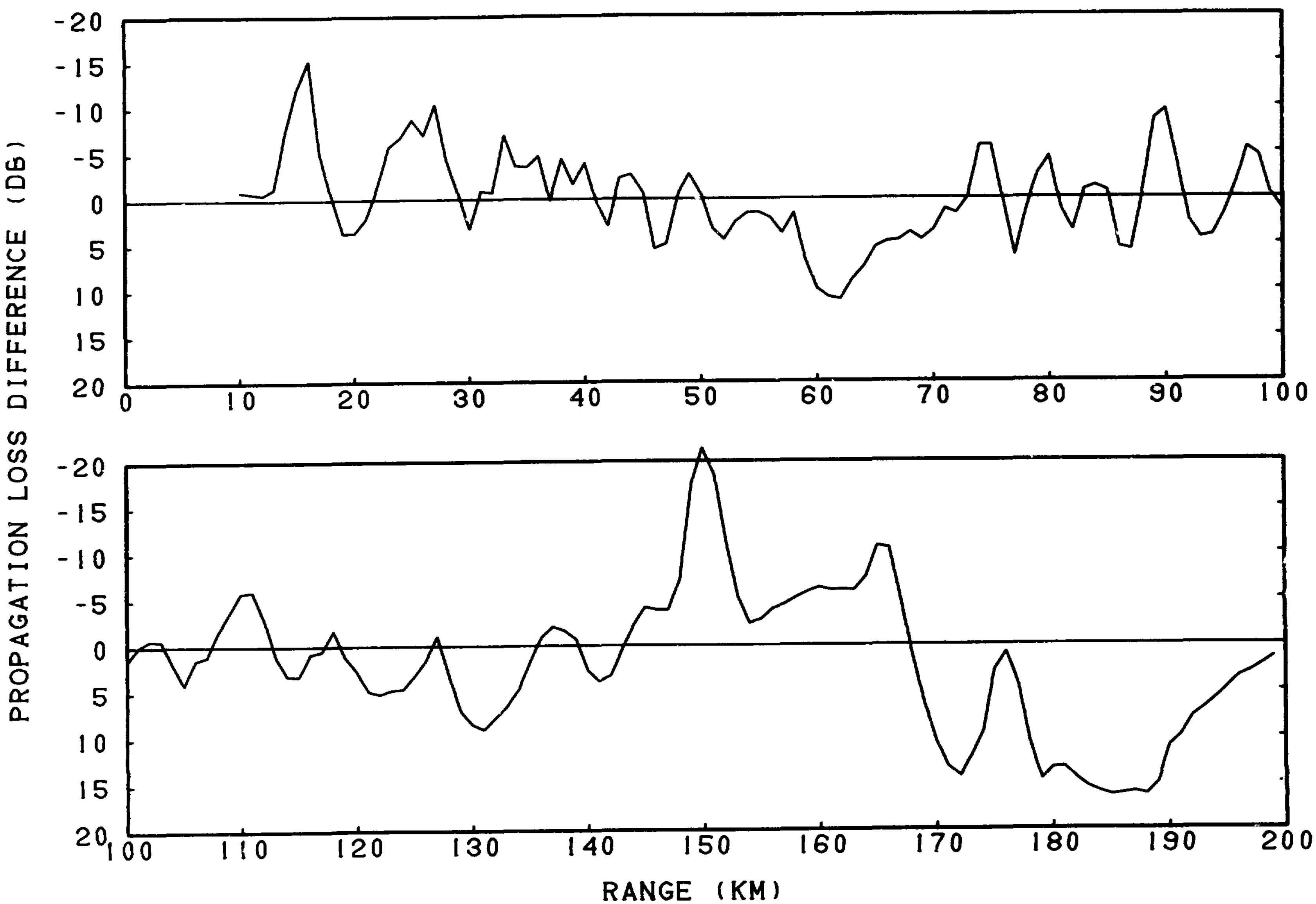
CONFIDENTIAL

(C) Figure IIC-22. FACT (Coherent) Bottom Loss = FNOC Type 3, Frequency = 400 Hertz



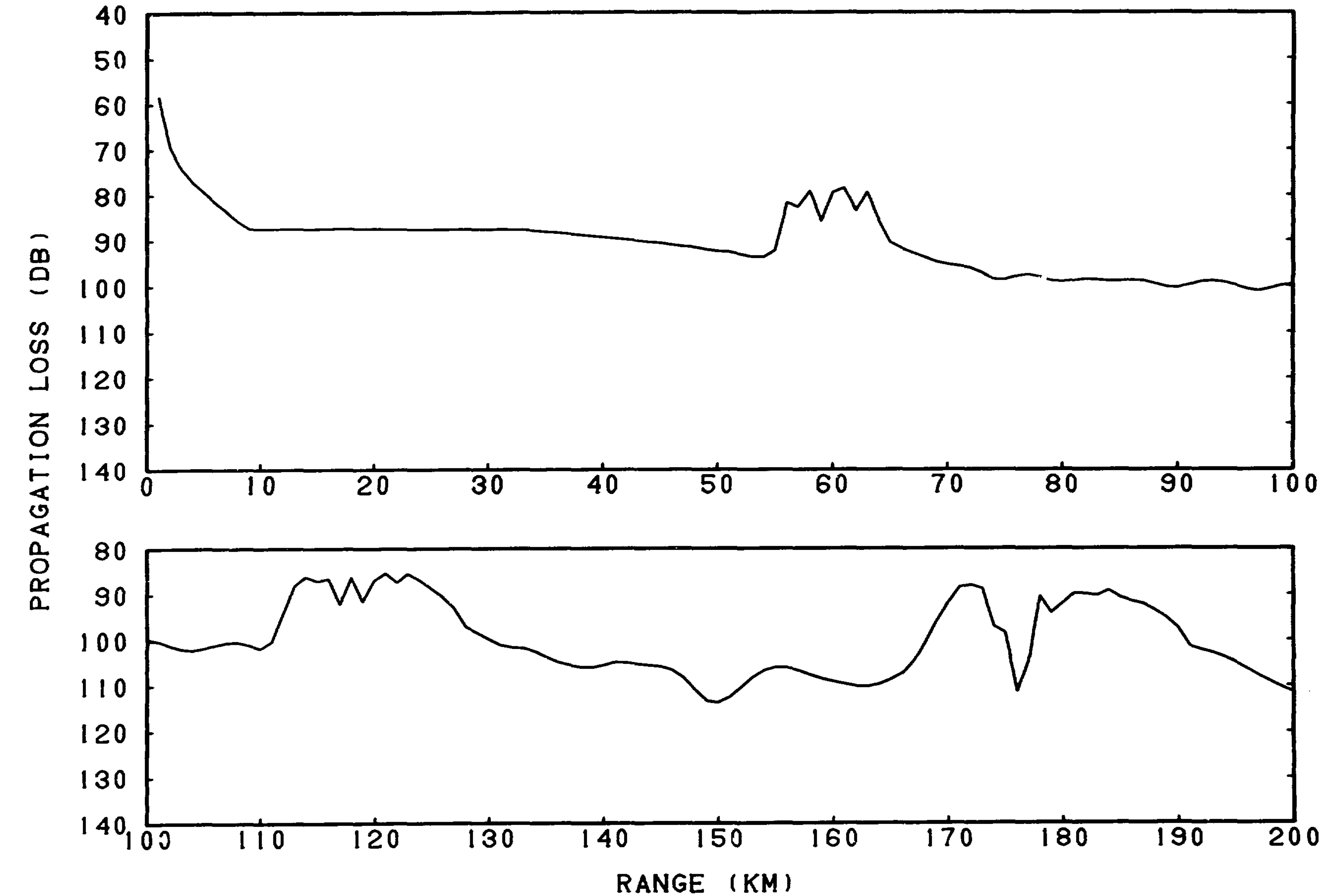
CONFIDENTIAL

(C) Figure IIC-23. FACT (Coherent) Bottom Loss = FNOC Type 3, Frequency = 400 Hertz, Sliding Averages of 3 Points (2.00 Kilometers)



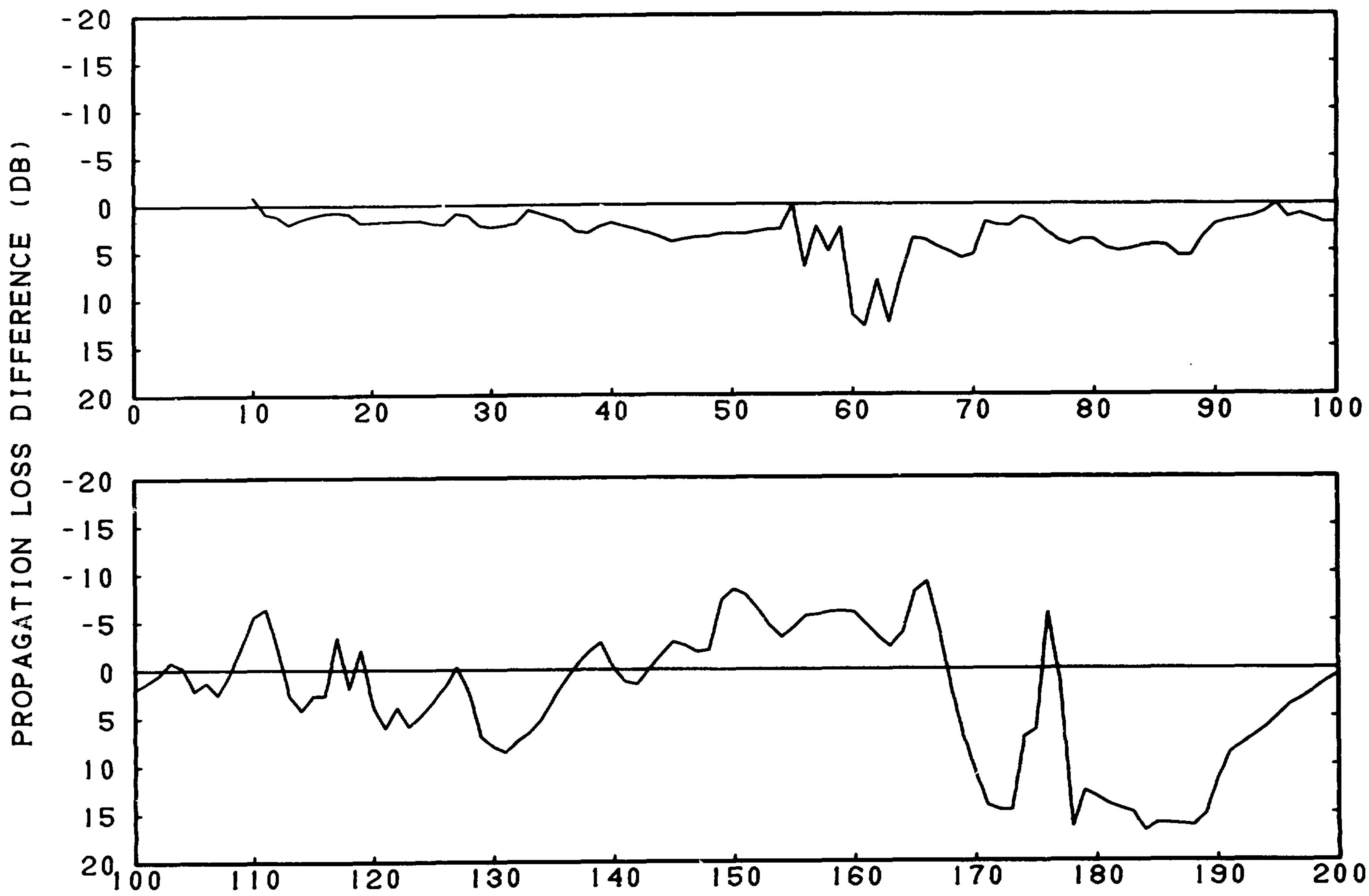
CONFIDENTIAL

(C) Figure IIC-24. Smoothed FACT (Coherent) Bottom Loss = FNOC Type 3, Subtracted from PARKA Data, Source Depth = 500 Feet, Receiver Depth = 300 Feet, Frequency = 400 Hertz



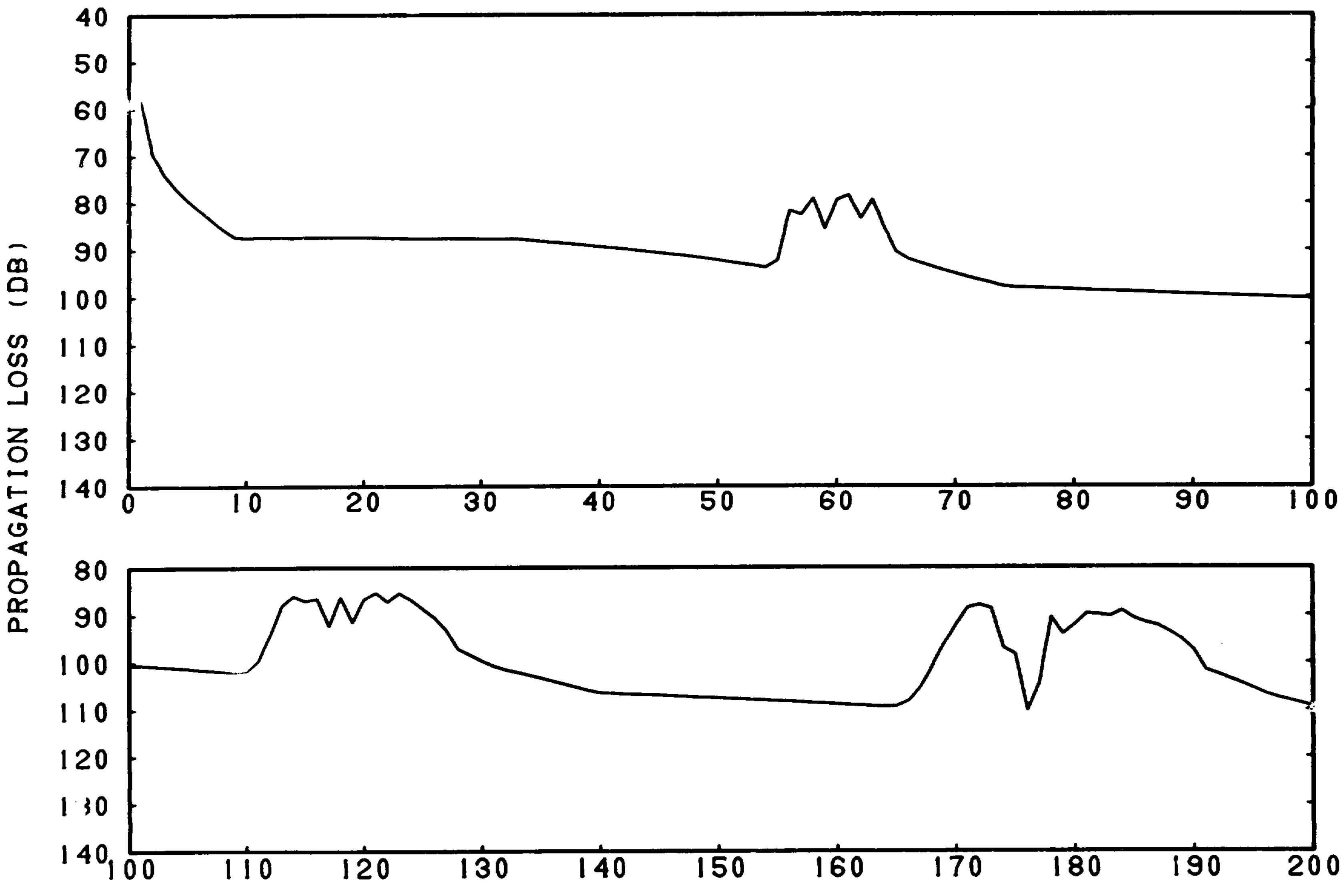
CONFIDENTIAL

(C) Figure IIC-25. FACT (Semi-coherent) Bottom Loss = FNOC Type 3
Frequency = 400 Hertz



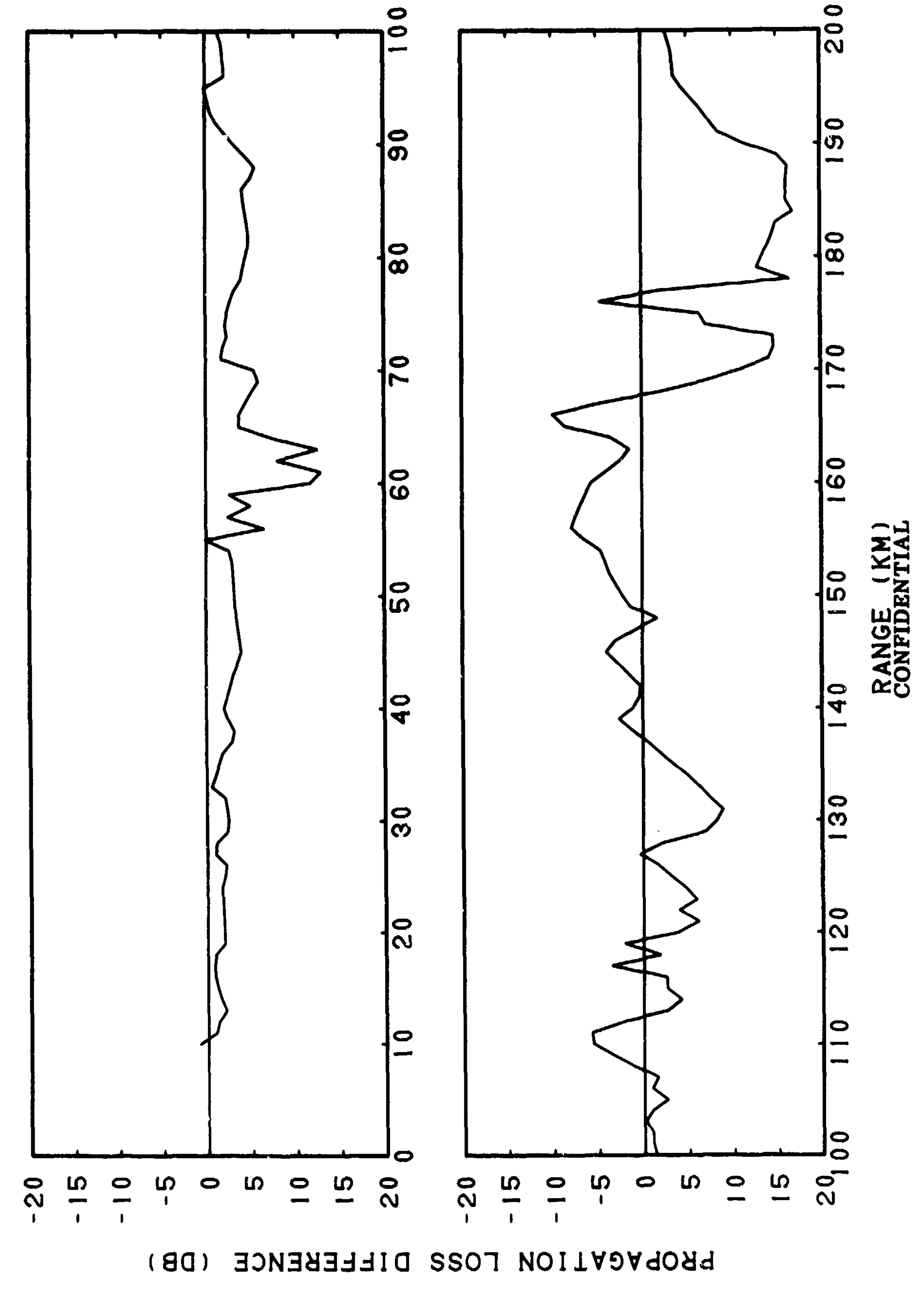
CONFIDENTIAL

(C) Figure IIC-26. FACT (Semi-coherent) Bottom Loss = FNOC Type 3, Frequency = 400 Hertz, Subtracted from PARKA Data, Source Depth = 500 Feet, Receiver Depth = 300 Feet, Frequency = 400 Hertz

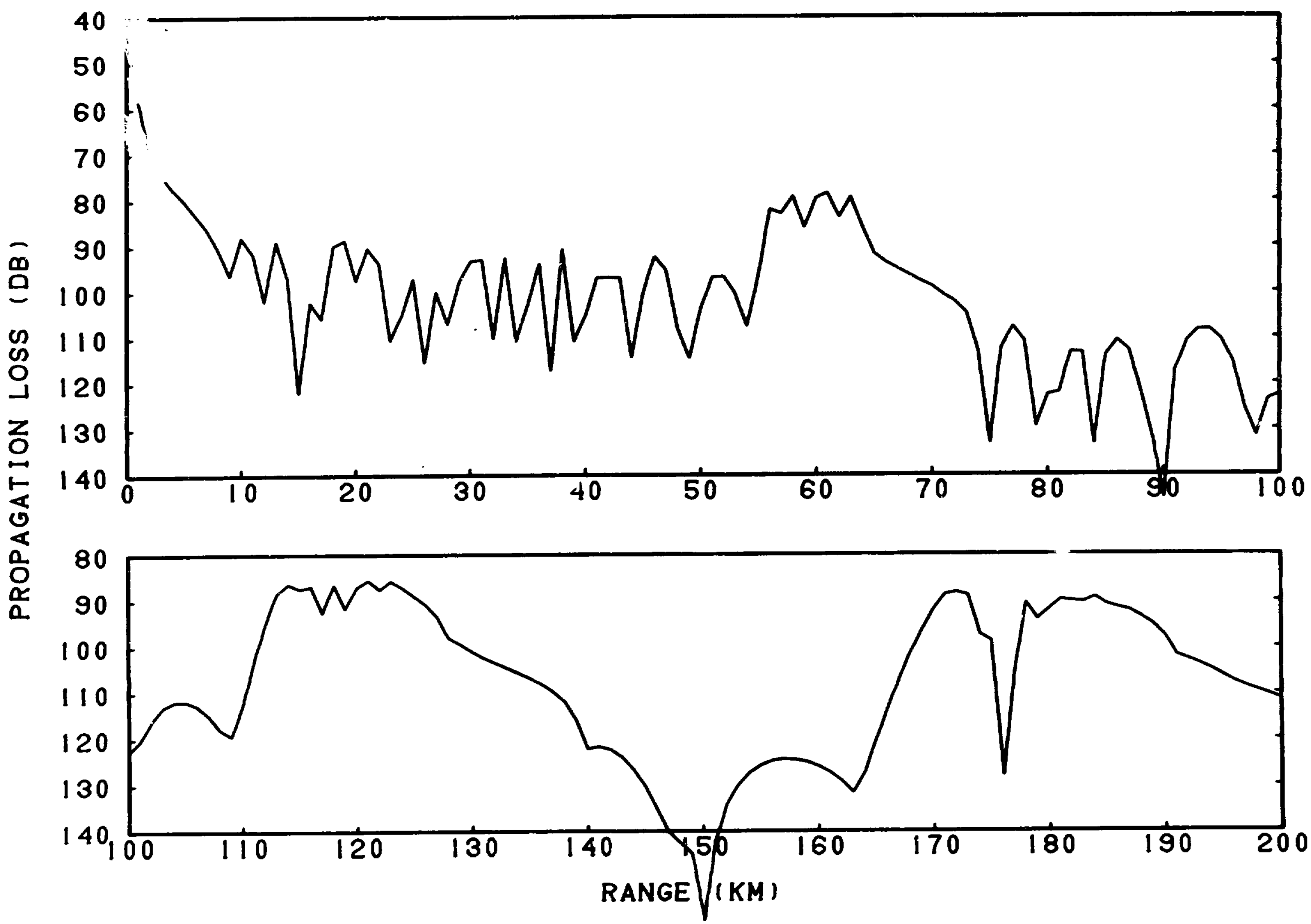


CONFIDENTIAL

(C) Figure IIC-27. FACT (Incoherent) Bottom Loss = FNOC Type 3, Frequency = 400 Hertz

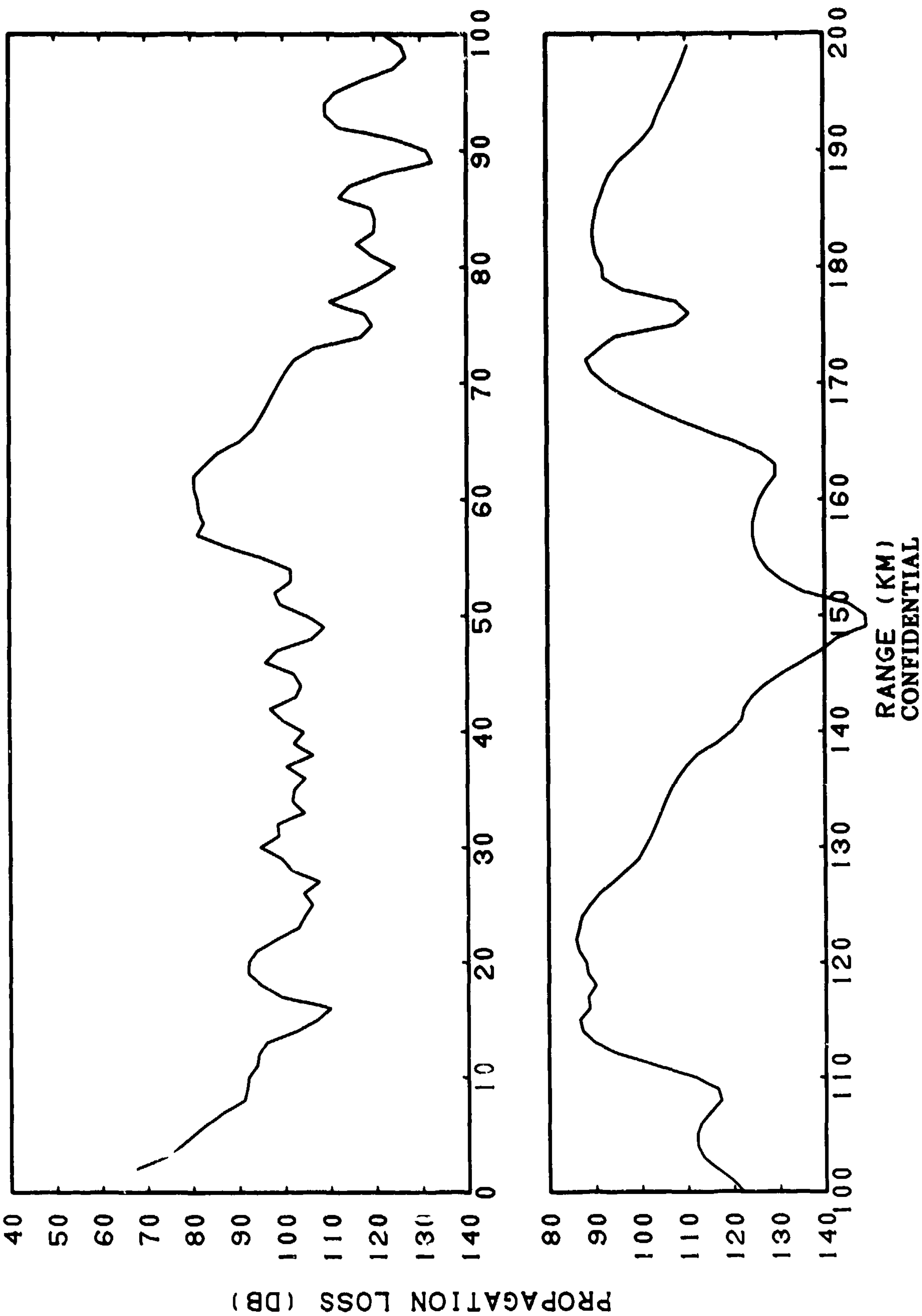


(C) Figure IIC-28. FACT (Incoherent) Bottom Loss = FNOC Type 3 Frequency = 400 Hertz, Subtracted from PARKA Data, Source Depth = 500 Feet, Receiver Depth = 300 Feet, Frequency = 400 Hertz

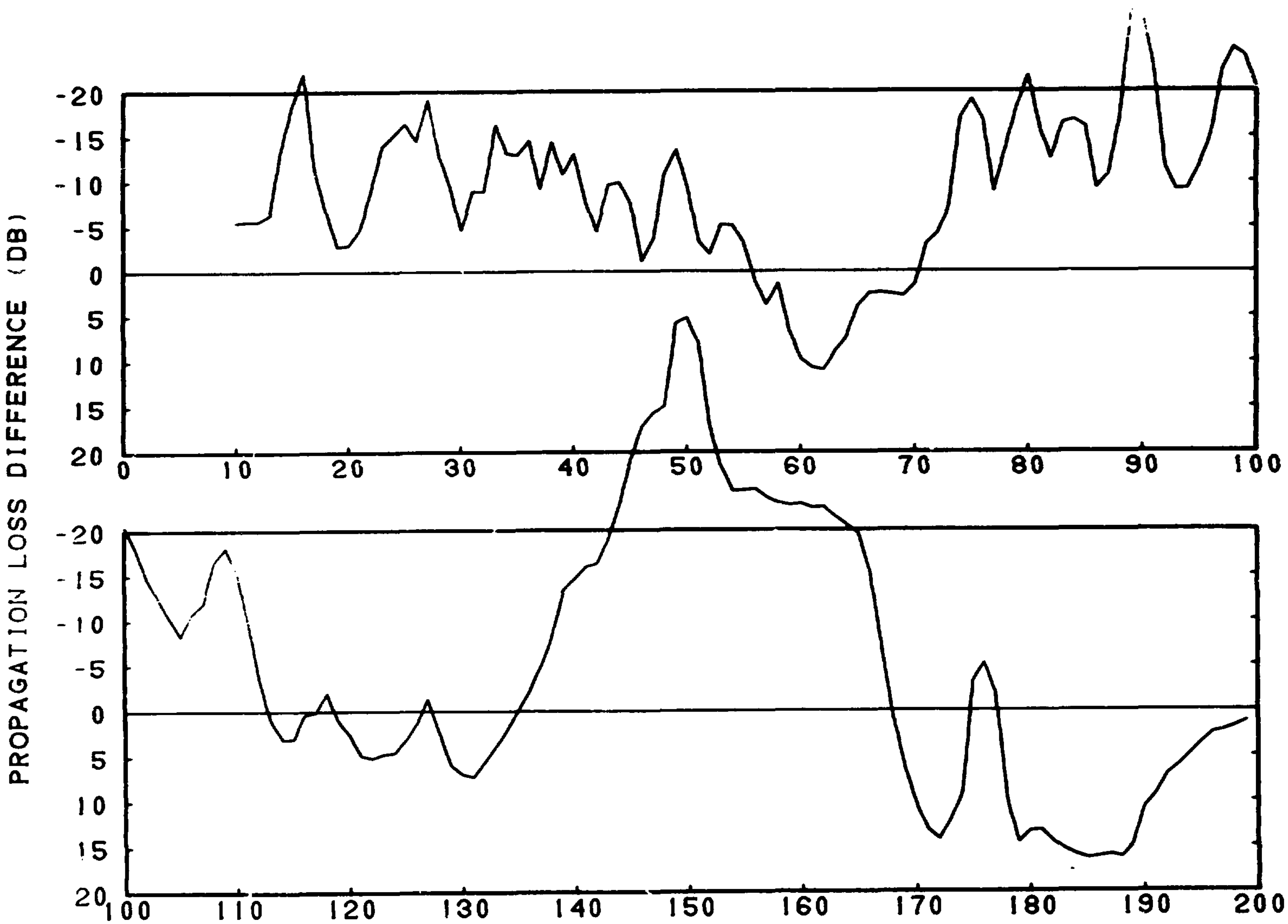


CONFIDENTIAL

(C) Figure IIC-29. FACT (Coherent) Bottom Loss = MGS 6, Frequency = 400 Hertz

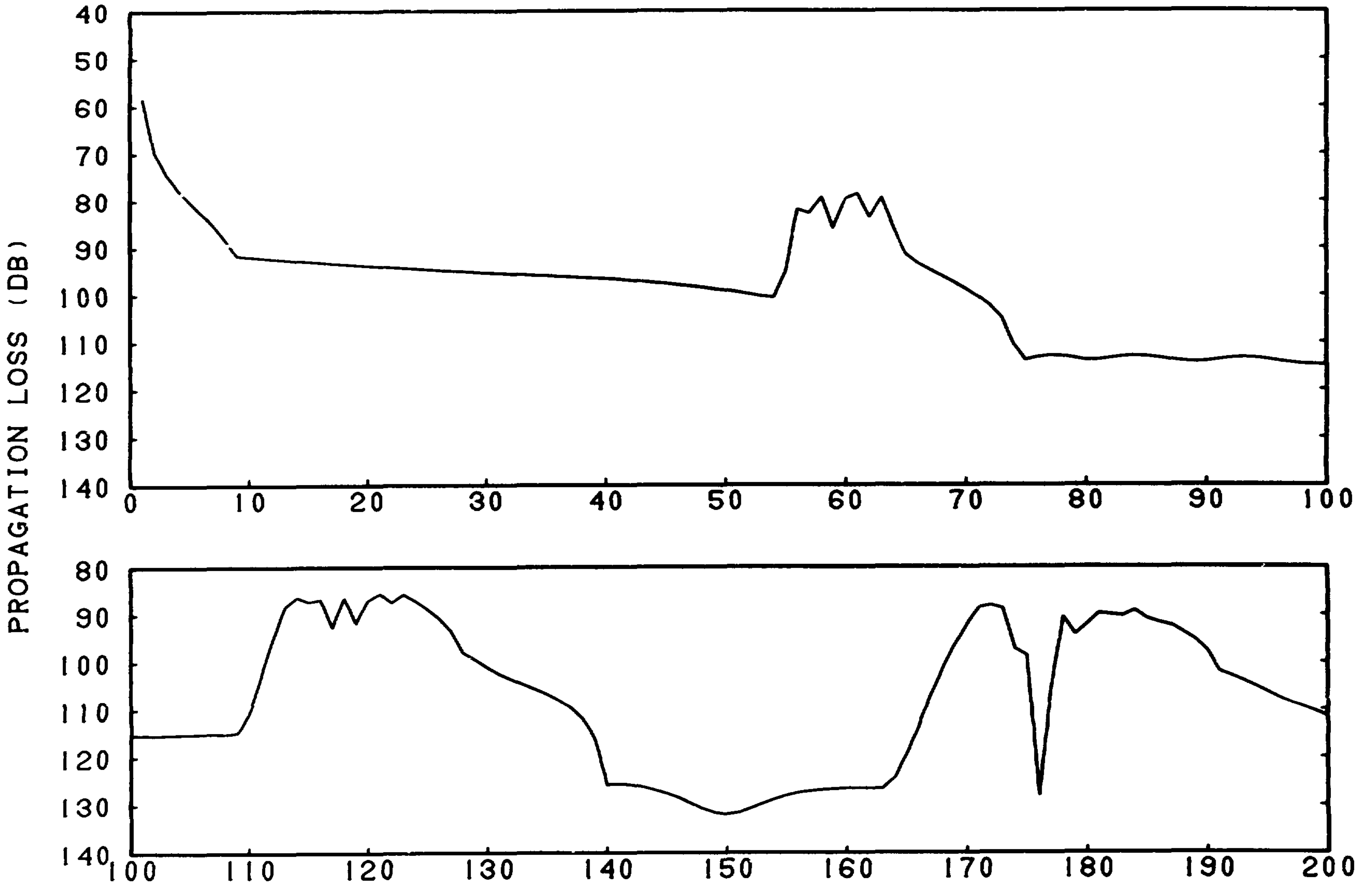


(C) Figure IIC-30. FACT (Coherent) Bottom Loss = MGS 6, Frequency = 400 Hertz, Sliding Averages of 3 Points (2.00 Kilometers)



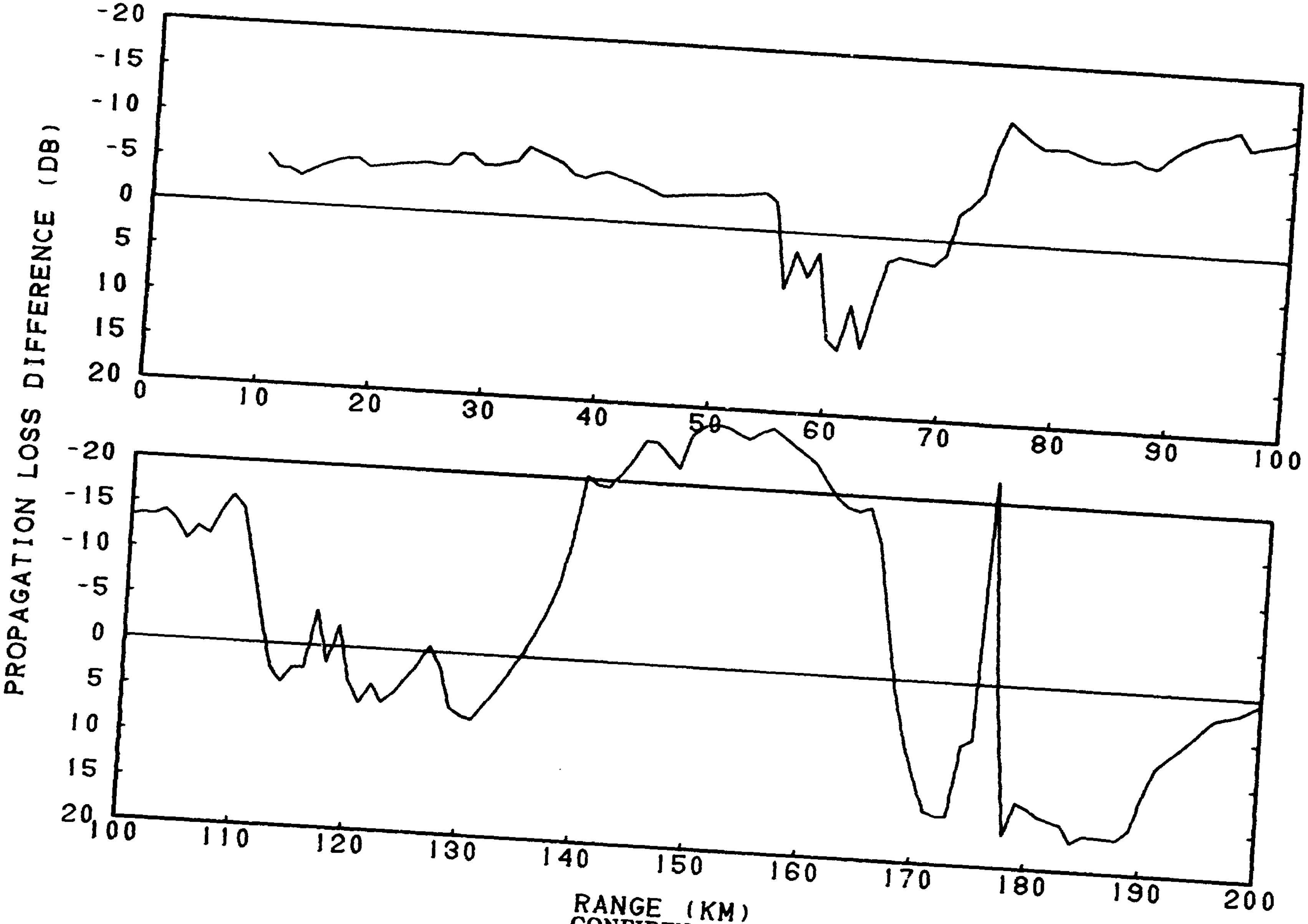
CONFIDENTIAL

(C) Figure IIC-31. Smoothed FACT (Coherent) B.ttom Loss = MGS 6, Frequency = 400 Hertz, Subtracted from PARKA Data, Source Depth = 500 Feet, Receiver Depth = 300 Feet, Frequency = 400 Hertz



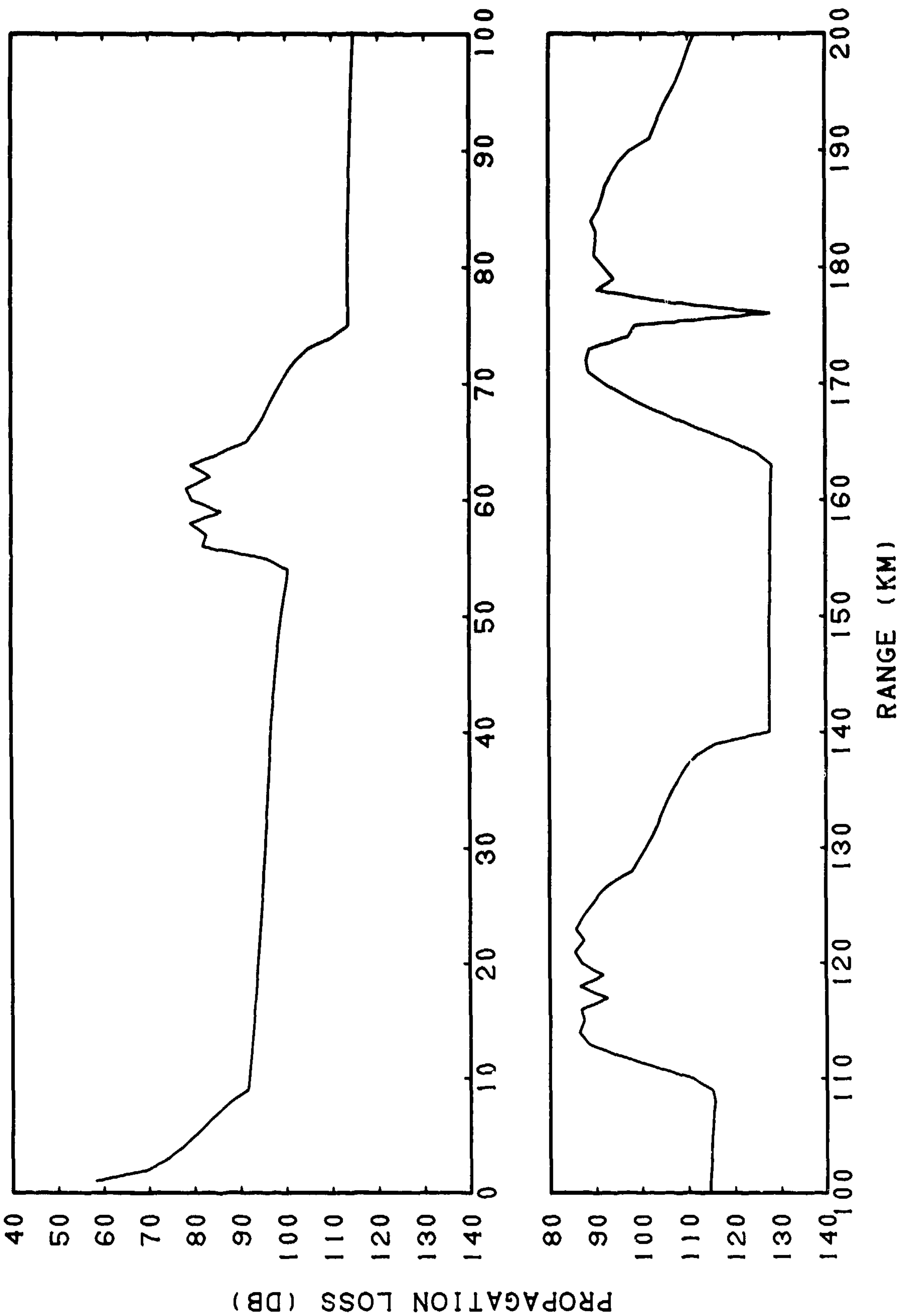
CONFIDENTIAL

(C) Figure IIC-32. FACT (Semi-coherent) Bottom Loss = MGS 6, Frequency = 400 Hertz



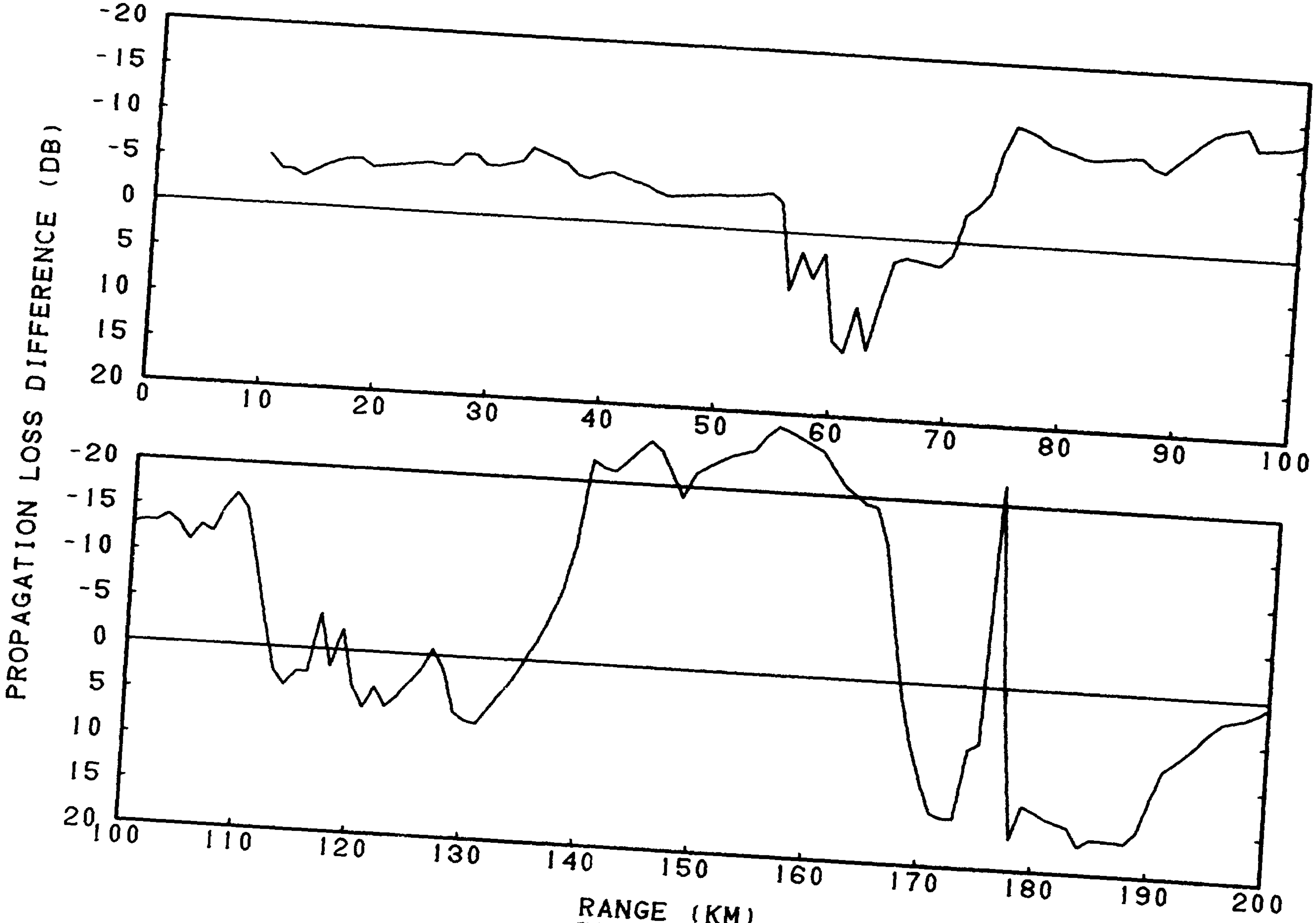
CONFIDENTIAL

(C) Figure IIC-33. FACT (Semi-coherent) Bottom Loss = MGS 6, Frequency = 400 Hertz, Subtracted from PARKA Data, Source Depth = 500 Feet, Receiver Depth = 300 Feet, Frequency = 400 Hertz



CONFIDENTIAL

(C) Figure IIC-34. FACT (Incoherent) Bottom Loss = MGS 6, Frequency = 400 Hertz



CONFIDENTIAL

(C) Figure IIC-35. FACT (Incoherent) Bottom Loss = MGS 6, Frequency = 400 Hertz, Subtracted from PARKA Data, Source Depth = 500 Feet, Receiver Depth = 300 Feet, Frequency = 400 Hertz

THIS

PAGE

INTENTIONALLY

LEFT

BLANK

Appendix IID. (U) Accuracy Assessment of FACT PL9D Compared to BEARING STAKE Experimental Data

BEARING STAKE (U)

Environment (U)

(C) The sound speed profile for station 1B, run P1, is given in Figure IID1. This profile is characterized by a broad deep sound channel, the breadth evidenced by a variation of 1 m/sec from 1500 m to the deep channel axis at 1725 m and a 1 m/sec increase to approxmately 2000 m. This profile is severely bottom limited.

(C) The bottom loss versus grazing angle for this environment is given in Figures IID2-IID4 and Tables IID1-IID3 for 25, 140 and 290 Hz. In all cases the loss is 0 dB at 0 degrees and 11.2 dB at normal incidence. At 5 degrees, the losses at 25, 140 and 290 Hz are 0.15, 0.73, and 1.27 dB, respectively; at 15 degrees, the values are 0.58, 1.83, and 3.15 dB. These experimentally determined bottom losses are lower than either the FACT internally stored values for a Type 1 area designator, the lowest loss routinely available to this model.

Test Cases (U)

(C) Station 1B, Run P1 consists of 12 cases as follows:

CASE	SOURCE DEPTH (m)	RECEIVER DEPTH (m)	FREQUENCY (Hz)
I	91	496	25
II	91	1685	25
III	91	3320	25
IV	91	3350	25
V	18	496	140
VI	18	1685	140
VII	18	3320	140
VIII	18	3350	140
IX	18	496	290
X	18	1685	290
XI	18	3320	290
XII	18	3350	290

CONFIDENTIAL

(C) In all cases the source is relatively shallow at either 18 or 91 m. Receiver depths are somewhat distributed over the water column with the deepest receiver on the bottom. The maximum range of the experimental data is 286 km. The FACT PL9D model, due to a 250 point maximum dimension, was run to a maximum range of 250 km to maintain a uniform spacing between points of 1 km. The Bearing Stake data for these cases are plotted in Figures IID5-IID16. The Bearing Stake experimental data exhibited substantial fluctuations and, in order to compare mean levels of model and experimental results, the experimental data were smoothed by applying a running average over a 2 km window. The smoothed experimental data, for the 12 cases, are given in Figures IID17- IID28.

Accuracy Assessment Results (U)

(U) The accuracy assessment procedures were followed as outlined in section 1.1 and described in detail in section 5 of Volume I of this series. The following figures were produced for each case: (1) FACT PL9D output using the semicoherent option, (2) the semi-coherent result subtracted from the smoothed Bearing Stake data. In all cases, the coherent, semicoherent, and incoherent coherence options provided the same output results. The results were generally smooth and any further smoothing of the model outputs would have been superfluous. The model results and the differences between the smoothed experimental data and the FACT PL9D model results are given (in pairs) in Figures IID29-IID52. The means and standard deviations of differences between the smoothed Bearing Stake data and the FACT PL9D model results are given in Table IID4. It is important, however, to quantify the effect upon the

statistics of the 2 km running average (equivalent to a sonar system with a 5 minute averaging time detecting a 12 knot submarine opening or closing on own-ship at 0 degrees or 180 degrees, respectively) as compared to no averaging. Differences between the unsmoothed (i.e., raw) Bearing Stake data and the FACT PL9D results were calculated. In general, the means for the unsmoothed results are about 0.2 dB greater (i.e., more positive) than those for the smoothed Bearing Stake data and the standard deviation is approximately 1 dB less. The difference in the two mean values is of an insignificant amount. The difference of the standard deviations, although not great, is significant and is clearly in the proper direction. The overall effects of smoothing the experimental data were consistent and not very great.

(C) The Bearing Stake experimental data did not have clearly definable regions, although some near-field interference patterns are in evidence. It was for this reason that the means and standard deviations are calculated over the entire range extent (the 250 km of the model results). As shall be shown below, this choice was not very useful and an arbitrary set of intervals such as 0-25, 25-50, 50-100, 100-200, $\geq$200 km would have been more useful. Conclusions based upon viewing the difference curves follow: (a) Case I: Difference curves oscillate between negative and positive values to 170 km after which all values are negative. Between 0 and 150 km there is an overall tendency to go from positive to negative difference (approximately -6 dB/150 km after eliminating the fluctuations). (b) Case II: Characterized by the same overall trend of differences becoming increasingly negative with range. Here, it is estimated that over the first 50 km a $\mu \simeq 0$ dB and $\sigma \simeq 2$ dB would be obtained. Past 200 km, a mean of approximately 7 dB is found with a standard deviation of 2-3 dB. (c) Case III: With occasional exception differences are essentially negative at a median level of -7 dB. There is no basic range dependence for this case. (d) Case IV: The differences rise (in terms of a running mean) from 0 to about 5 dB over the first 150 km and rise slowly from $\simeq$7 to $\simeq$8 dB over the next 100 km. The standard deviation of 3 dB found in the table is essentially constant over the 250 km interval. With one exception all differences are positive past 100 km. (e) Case V: The differences show a continuing trend from positive to negative over the 250 km extent the rise being 11 dB/150 km over the first 150 km. All differences are positive past 140 km, (f) Case VI: Mean differences go from positive to negative with increasing range, the transition being at about 60 km. A steady state mean difference of $\simeq$-5 dB is reached after 185 km. (g) Case VII: The overall plus to minus trend in differences is repeated but more rapidly (all differences past 62 km negative). This case is replete with large fluctuations as evidenced by the overall standard deviation of 5.2 dB. (h) Case VIII: Essentially the same as Case VII. (i) Case IX: Once again the positive-to-negative trend in differences. Differences negative to 50 km; oscillatory negative to positive 50-140 km; positive past 140 km. (j) Case X: Similar behavior to Case IX but transition ranges are approximately 80 and 145 km. Marked "increase" in negative values observed toward end (>210 km) of record. (k) Case XI: The most extreme case of the positive to negative trend - overall range in differences $\simeq$25 dB. Reasonable agreement between 100 and 135 km. (l) Case XII: Basically the same form as Case XI but somewhat attenuated. Basic agreement area 85-135 km.

(C) Two basic conclusions may be reached upon comparing the Bearing Stake experimental data with FACT PL9D model results (1) The model fails to capture, at all ranges and, regardless of coherence option chosen, the basic fluctuating nature of the experimental data (all coherence options yielded the same values). This suggests a close examination of the FACT coherence logic, particularly in Bearing Stake type

environments. (2) The basic trend of the disagreements is that the differences go from positive at short range to negative at long range (the overall statistical effect being an emphasis of the negative differences). It appears that at great range, an even smaller bottom loss than that measured would be necessary to bring the model into agreement with measured data. But what of shorter ranges where the experimental data has less loss than the model results? The answer may lie in the treatment of coherence. The resolution of this matter bears further investigation. We now turn to the effect of these differences on detection range as a function of figure of merit. The results of this analysis are contained in Tables IID5-IID16. The results cited above are generally replicated in the FOM analysis, i.e., the FACT PL9D model gives longer continuous detection ranges (i.e., range to which detection opportunity is 100%), but because of fluctuations, the experimental data gives longer zonal coverage. The experimental data generally predicts detections at longer ranges than would be concluded from examining the model results.

(C) Table IID-1. Bearing Stake Station 1B, Run P1. Bottom Loss (dB) versus Grazing Angle (degrees). Frequency = 25 Hertz.

Θ	BL	Θ	BL	Θ	BL	Θ	BL	Θ	BL	Θ	BL
0	0.00	15	0.55	30	4.20	45	10.40	60	11.20	75	11.20
1	0.05	16	0.70	31	4.80	46	10.45	61	11.20	76	11.20
2	0.075	17	0.85	32	5.60	47	10.50	62	11.20	77	11.20
3	0.10	18	1.00	33	6.20	48	10.60	63	11.20	78	11.20
4	0.15	19	1.10	34	6.90	49	10.70	64	11.20	79	11.20
5	0.20	20	1.30	35	7.60	50	10.75	65	11.20	80	11.20
6	0.25	21	1.50	36	8.20	51	10.80	66	11.20	81	11.20
7	0.30	22	1.60	37	8.90	52	10.90	67	11.20	82	11.20
8	0.35	23	1.70	38	9.70	53	10.95	68	11.20	83	11.20
9	0.40	24	2.00	39	10.10	54	11.00	69	11.20	84	11.20
10	0.45	25	2.20	40	10.15	55	11.05	70	11.20	85	11.20
11	0.50	26	2.60	41	10.20	56	11.10	71	11.20	86	11.20
12	0.55	27	2.80	42	10.25	57	11.15	72	11.20	87	11.20
13	0.60	28	3.20	43	10.30	58	11.20	73	11.20	88	11.20
14	0.58	29	3.50	44	10.35	59	11.20	74	11.20	89	11.20

CONFIDENTIAL

(C) Table IID-2. Bearing Stake Station 1B, Run P1. Bottom Loss (dB) versus Grazing Angle (degrees). Frequency = 140 Hertz.

Θ	BL	Θ	BL	Θ	BL	Θ	BL	Θ	BL	Θ	BL
0	0.00	15	1.83	30	4.13	45	10.43	60	11.20	75	11.20
1	0.13	16	1.83	31	4.33	46	10.53	61	11.20	76	11.20
2	0.33	17	1.83	32	4.63	47	10.63	62	11.20	77	11.20
3	0.53	18	1.91	33	5.03	48	10.73	63	11.20	78	11.20
4	0.79	19	2.13	34	5.63	49	10.74	64	11.20	79	11.20
5	0.93	20	2.23	35	6.23	50	10.83	65	11.20	80	11.20
6	1.18	21	2.33	36	6.93	51	10.84	66	11.20	81	11.20
7	1.33	22	2.43	37	7.53	52	10.85	67	11.20	82	11.20
8	1.53	23	2.63	38	8.13	53	10.86	68	11.20	83	11.20
9	1.53	24	2.83	39	8.63	54	10.92	69	11.20	84	11.20
10	1.68	25	2.93	40	9.13	55	10.93	70	11.20	85	11.20
11	1.73	26	3.23	41	9.63	56	10.94	71	11.20	86	11.20
12	1.78	27	3.33	42	10.13	57	11.01	72	11.20	87	11.20
13	1.83	28	3.63	43	10.23	58	11.02	73	11.20	88	11.20
14	1.83	29	3.83	44	10.33	59	11.03	74	11.20	89	11.20

CONFIDENTIAL

(C) Table IID-3. Bearing Stake Station 1B, Run P1. Bottom Loss (dB) versus Grazing Angle (degrees). Frequency = 290 Hertz.

Θ	BL	Θ	BL	Θ	BL	Θ	BL	Θ	BL	Θ	BL
0	0.00	15	3.17	30	6.37	45	10.67	60	11.20	75	11.20
1	0.27	16	3.18	31	6.57	46	10.87	61	11.20	76	11.20
2	0.67	17	3.19	32	6.77	47	11.07	62	11.20	77	11.20
3	0.97	18	3.37	33	6.97	48	11.20	63	11.20	78	11.20
4	1.27	19	3.57	34	7.47	49	11.20	64	11.20	79	11.20
5	1.57	20	3.77	35	7.97	50	11.20	65	11.20	80	11.20
6	1.87	21	3.97	36	8.27	51	11.20	66	11.20	81	11.20
7	2.17	22	4.19	37	8.67	52	11.20	67	11.20	82	11.20
8	2.37	23	4.57	38	9.27	53	11.20	68	11.20	83	11.20
9	2.47	24	4.77	39	9.67	54	11.20	69	11.20	84	11.20
10	2.67	25	5.17	40	9.77	55	11.20	70	11.20	85	11.20
11	2.77	26	5.37	41	9.97	56	11.20	71	11.20	86	11.20
12	2.87	27	5.67	42	10.17	57	11.20	72	11.20	87	11.20
13	3.07	28	5.97	43	10.27	58	11.20	73	11.20	88	11.20
14	3.15	29	6.17	44	10.47	59	11.20	74	11.20	89	11.20

CONFIDENTIAL

(C) Table IID-4. Means and Standard Deviations of Differences Between Bearing Stake Data Smoothed[1] and FACT PL9D[2] Model Results.

Station	Run	Source Depth (m)	Receiver Depth (m)	Frequency (Hz)	μ (dB)	σ (dB)
1B	P1	91	496	25	-2.5	4.5
1B	P1	91	1685	25	-3.6	3.9
1B	P1	91	3320	25	-5.0	4.5
1B	P1	91	3350	25	-4.9	3.2
1B	P1	18	496	140	-2.4	4.9
1B	P1	18	1685	140	-2.4	3.4
1B	P1	18	3320	140	-5.0	5.2
1B	P1	18	3350	140	-4.6	5.0
1B	P1	18	496	290	-2.0	5.1
1B	P1	18	1685	290	-1.3	5.0
1B	P1	18	3320	290	-0.8	6.5
1B	P1	18	3350	290	-0.8	6.0

1. Smoothed by application of a 2km-window running average.
2. All FACT PL9D results identical - independent of phase option chosen.

CONFIDENTIAL

(C) Table IID-5. Detection Range in km as a Function of Figure of Merit (FOM) in dB for Bearing Stake Data[1] and FACT PL9D Model[2] Results (Station 1B Run P1, Source Depth = 91 m, Receiver Depth = 496 m, Frequency = 25 Hz)

Data Set	FOM	R_c[3]	Range > R_c
Bearing Stake	75	5.5	ZDC[4] 15%, 5.5-31 km.
FACT PL9D	75	7	
Bearing Stake	80	6	ZDC 50%, 6-32 km. ZDC 5-10%, 32-90.5 km.
FACT PL9D	80	25.5	
Bearing Stake	85	6.5	ZDC 65%, 6.5-98 km. ZDC 15%, 90.5-175 km.
FACT PL9D	85	61	
Bearing Stake	90	65.5	ZDC 85%, 65.5-150 km. ZDC 30%, 150-243 km.
FACT PL9D	90	99.5	
Bearing Stake	95	76	100% coverage (except for dropouts at 76 & 168 km) to 235 km, ZDC 85% 235->287 km.
FACT PL9D	95	227	
Bearing Stake	100	77	100% coverage (except for dropouts at 76 & 168 km) to >287 km.
FACT PL9D	100	>287	

1. Smoothed by running average with 2 kilometer window.
2. Coherent, semi-coherent and incoherent results were identical; no smoothing was used.
3. R_c = Range to which detection coverage is continuous.
4. ZDC - Zonal Detection Coverage in percentage of range interval over which detection can be made.

CONFIDENTIAL

(C) Table IID-6. Detection Range in km as a Function of Figure of Merit (FOM) in dB for Bearing Stake Data[1] and FACT PL9D Model[2] Results (Station 1B, Run P1, Source Depth = 91m, Receiver Depth = 1685 m, Frequency = 25 Hz)

Data Set	FOM	R_c[3]	Range > R_c
Bearing Stake	75	12	One small peak (1 point) at 19 km.
FACT PL9D	75	12.5	
Bearing Stake	80	13	ZDC[4] 70%, 13-44 km.
FACT PL9D	80	23	
Bearing Stake	85	25	ZDC 95%, 25-66 km; ZDC 50%, 66-119 km; ZDC 15%, 119-199 km.
FACT PL9D	85	56	
Bearing Stake	90	75	ZDC 95%, 75 - 149 km; ZDC 60%, 149-196 km; ZDC 10%, 196 - 186 km.
FACT PL9D	90	94	
Bearing Stake	95	76	ZDC 95%, 76 - 256 km; ZDC 80%, 256 ->287 km.
FACT PL9D	95	193.5	
Bearing Stake	100	76.5	100% coverage (except for dropouts at 76.5 and 167.5 km) to >287 km.
FACT PL9D	100	>287	

1. Smoothed by running average with 2 kilometer window.
2. Coherent, semicoherent, and incoherent results were identical; no smoothing was used.
3. R_c = Range to which detection coverage is continuous.
4. ZDC = Zonal Detection Coverage in percentage of range interval over which detection can be made.

CONFIDENTIAL

(C) Table IID-7. Detection Range in km as a Function of Figure of Merit (FOM) in dB for Bearing Stake Data[1] and FACT PL9D Model[2] Results. (Station 1B, Run P1, Source Depth = 91m, Receiver Depth = 3320 m, Frequency = 25 Hz)

Data Set	FOM	R_c [3]	Range > R_c
Bearing Stake	75	5	ZDC[4] 85%, 5 - 32 km.
FACT PL9D	75	12.5	
Bearing Stake	80	6	ZDC 90%, 6 - 71.5 km.
FACT PL9D	80	29	
Bearing Stake	85	75	ZDC 65%, 75 - 140 km; ZDC 50%, 140 - 225 km; ZDC 20%, 225 - 286 km.
FACT PL9D	85	69.5	
Bearing Stake	90	75.5	ZDC 90%, 75.5 - 286 km.
FACT PL9D	90	111	100% coverage 121 - 124 km.
Bearing Stake	95	76	100% coverage (except for dropouts at 76 & 168 km) to >286 km.
FACT PL9D	95	221	100% coverage 232 - 242 km.
Bearing Stake	100	76.5	100% coverage (except for dropouts at 76 & 168 km) to >286 km.
FACT PL9D	100	>286	

1. Smoothed by running average with a 2 kilometer window.
2. Coherent, semicoherent, and incoherent results were identical; no smoothing was used.
3. R_c = Range to which detection coverage is continuous.
4. ZDC = Zonal Detection Coverage in percentage of range interval over which detection can be made.

CONFIDENTIAL

(C) Table IID-8. Detection Range in km as a Function of Figure of Merit (FOM) in dB for Bearing Stake Data[1] and FACT PL9D Model[2] Results. (Station 1B, Run P1, Source Depth = 91m, Receiver Depth = 3350 m, Frequency = 25 Hz)

Data Set	FOM	R_c[3]	Range > R_c
Bearing Stake	75	6	ZDC[4] 95%, 6 - 19 km.
FACT PL9D	75	13	100% coverage 19.5 - 21 km.
Bearing Stake	80	35	ZDC 60%, 35 - 69 km; 100% coverage 87 - 90 km.
FACT PL9D	80	29	
Bearing Stake	85	80	ZDC 70%, 80 - 150 km; ZDC 20%, 150 - 286 km.
FACT PL9D	85	68.5	
Bearing Stake	90	150	ZDC 90%, 150 - 286 km.
FACT PL9D	90	110	100% coverage 126 - 129 km.
Bearing Stake	95	>286	
FACT PL9D	95	=286	

1. Smoothed by running average with a 2 kilometer window.
2. Coherent, semicoherent, and incoherent results were identical; no smoothing was used.
3. R_c = Range to which detection coverage is continuous.
4. ZDC = Zonal Detection Coverage in percentage of range interval over which detection can be made.

CONFIDENTIAL

(C) Table IID-9. Detection Range in km as a Function of Figure of Merit (FOM) in dB for Bearing Stake Data[1] and FACT PL9D Model[2] Results.
(Station 1B, Run P1, Source Depth = 18m, Receiver Depth = 496 m, Frequency = 140 Hz)

Data Set	FOM	R_c[3]	Range>R_c
Bearing Stake	75	5	
FACT PL9D	75	5.5	
Bearing Stake	80	6	100% coverage 30.5 - 34 km.
FACT PL9D	80	17.5	
Bearing Stake	85	7	ZDC[4] 50%, 7 - 41 km.
FACT PL9D	85	43.5	
Bearing Stake	90	8	100% coverage, 11 - 44 km; ZDC 55%, 44 - 115 km.
FACT PL9D	90	75	
Bearing Stake	95	41	ZDC 75%, 41 - 150 km; ZDC 15%, 150 - 247.5 km.
FACT PL9D	95	113	
Bearing Stake	100	136.5	ZDC 95%, 136.5 - 249 km.
FACT PL9D	100	161	
Bearing Stake	105	251	ZDC 90%, 251 - 286 km.
FACT PL9D	105	236	

1. Smoothed by running average with a 2 kilometer window.
2. Coherent, semicoherent, and incoherent results were identical; no smoothing was used.
3. R_c = Range to which detection coverage is continuous.
4. ZDC = Zonal Detection Coverage in percentage of range interval over which detection can be made.

CONFIDENTIAL

(C) Table IID-10. Detection Range in km as a Function of Figure of Merit (FOM) in dB for Bearing Stake Data[1] and FACT PL9D Model Results. (Station 1B, Run P1, Source Depth = 18m, Receiver Depth = 1685 m, Frequency = 140 Hz)

Data Set	FOM	R_c [3]	Range > R_c
Bearing Stake	75	6.5	100% coverage, 8 - 10 km.
FACT PL9D	75	10.5	
Bearing Stake	80	11	ZDC[4] 25%, 11 - 21 km.
FACT PL9D	80	15.5	
Bearing Stake	85	15.5	ZDC 45%, 20 - 48 km.
FACT PL9D	85	20.5	
Bearing Stake	90	43.5	ZDC 95%, 45 - 67 km; ZDC 25%, 67 - 115.5 km.
FACT PL9D	90	67.5	
Bearing Stake	95	129	ZDC 85%, 129 - 150 km; ZDC 20%, 150 - 216.5 km.
FACT PL9D	95	106.5	
Bearing Stake	100	157.5	ZDC 85%, 157.5 - 226.5 km; ZDC 20%, 226.5 - 286 km
FACT PL9D	100	149	100% coverage 159.5 - 165 km.
Bearing Stake	105	162	100% coverage (except 162 - 166 km) to >286 km.
FACT PL9D	105	222.5	

1. Smoothed by running average with a 2 kilometer window.
2. Coherent, semicoherent, and incoherent results were identical; no smoothing was used.
3. R_c = Range to which detection coverage is continuous.
4. ZDC = Zonal Detection Coverage in percentage of range interval over which detection can be made.

(C) Table IID-11. Detection Range in km as a Function of Figure of Merit (FOM) in dB for Bearing Stake Data[1] and FACT PL9D Model[2] Results. (Station 1B, Run P1, Source Depth = 18m, Receiver Depth = 3320 m, Frequency = 140 Hz)

Data Set	FOM	R_c[3]	Range > R_c
Bearing Stake	75	?	ZDC[4] 50% to 18.5 km.
FACT PL9D	75	12	100% coverage 18 - 20 km.
Bearing Stake	80	9	ZDC [illegible]0%, 9 - 20 km - 100% coverage 45 - 50 km.
FACT PL9D	80	21	
Bearing Stake	85	24	ZDC 50%, 24 - 84 km; ZDC 5%, 84 - 130 km.
FACT PL9D	85	33.5	100% coverage 55.5 - 58.5 km.
Bearing Stake	90	24	100% coverage (except for dropouts at 24 & 59 km) to 141.5 km; ZDC 15%, 141.5 - 215.5 km.
FACT PL9D	90	62.5	100% coverage 93.5 - 96 km.
Bearing Stake	95	141.5	ZDC 65%, 141 - 249 km.
FACT PL9D	95	102	100% coverage 131 - 137.5 km.
Bearing Stake	100	143	ZDC 15%, 143 - 286 km.
FACT PL9D	100	144	100% coverage 163 - 179 km.
Bearing Stake	105	253.5	100% coverage (except from 253.5 to 256 km) to 286 km.
FACT P[illegible]9D	105	225	100% coverage 14[illegible] -> 150 km.

1. Smoothed by running average with a 2 kilometer window.
2. Coherent, semicoherent, and incoherent results were identical; no smoothing was used.
3. R_c = Range to which detection coverage is continuous.
4. ZDC = Zonal Detection Coverage in percentage of range interval over which detection can be made.

CONFIDENTIAL

(C) Table IID-12. Detection Range in km as a Function of Figure of Merit (FOM) in dB for Bearing Stake Data[1] and FACT PL9D Model[2] Results. (Station 1B, Run P1, Source Depth = 18 m, Receiver Depth = 3350 m, Frequency = 140 Hz).

Data Set	FOM	R_c[3]	Range > R_c
Bearing Stake	75	?	ZDC[4] 50%, 4 - 18 km.
FACT PL9D	75	12	100% coverage 18 - 19 km.
Bearing Stake	80	10.5	100% coverage 12.5 - 20 km and 46 - 50 km.
FACT PL9D	80	20.5	
Bearing Stake	85	30.5	ZDC 50%, 30.5 - 57 km; ZDC 5%, 57 - 131.5 km.
FACT PL9D	85	33	100% coverage 55 - 58 km.
Bearing Stake	90	32	ZDC 75%, 32 - 100 km; ZDC 50%, 100 - 148 km.
FACT PL9D	90	62.5	100% coverage 93 - 96 km.
Bearing Stake	95	34	100% coverage (except 34 - 37 and 60 - 61 km) to 165 km; ZDC 50%, 165 - 233 km - ZDC 20%; 233 - 273 km.
FACT PL9D	95	101.5	100% coverage 130.5 - 138 km.
Bearing Stake	100	254	ZDC 50%, 254 - 286 km.
FACT PL9D	100	143.5	100% coverage 160 - 179 km.
Bearing Stake	105	255	100% coverage (except 255 - 258) to > 286 km.
FACT PL9D	105	223	100% coverage 242 -> 250 km.

1. Smoothed by running average with a 2 kilometer window.
2. Coherent, semicoherent, and incoherent results were identical; no smoothing was used.
3. R_c = Range to which detection coverage is continuous.
4. ZDC = Zonal Detection Coverage in percentage of range interval over which detection can be made.

(C) Table IID-13. Detection Range in km as a Function of Figure of Merit (FOM) in dB for Bearing Stake Data[1] and FACT PL9D Model[2] Results. (Station 1B, Run P1, Source Depth = 18m, Receiver Depth = 496 m, Frequency = 290 Hz)

Data Set	FOM	R_c [3]	Range > R_c
Bearing Stake	75	4.5	
FACT PL9D	75	6	
Bearing Stake	80	5.5	
FACT PL9D	80	7	
Bearing Stake	85	8	ZDC[4] 25%, 8 - 37 km.
FACT PL9D	85	35.5	
Bearing Stake	90	23	ZDC 90%, 23 - 44 km; ZDC 25%, 44 - 84 km; ZDC 5%, 84 - 183 km.
FACT PL9D	90	45.5	100% coverage 70 - 72 km.
Bearing Stake	95	50.5	ZDC 70%, 50.5 - 90 km; ZDC 15%, 90 - 183 km.
FACT PL9D	95	83	
Bearing Stake	100	60.5	ZDC 95%, 60.5 - 89.5 km; ZDC 60%, 89.5 - 208
FACT PL9D	100	121.5	
Bearing Stake	105	93	ZDC 90%, 93 - 163 km; ZDC 75%, 163 - 237.5
FACT PL9D	105	158	
Bearing Stake	110	173	ZDC 95%, 173 - 250 km; ZDC 35%, 258 - 286 km
FACT PL9D	110	200	

1. Smoothed by running average with a 2 kilometer window.
2. Coherent, semicoherent, and incoherent results were identical; no smoothing was used.
3. R_c = Range to which detection coverage is continuous.
4. ZDC = Zonal Detection Coverage in percentage of range interval over which detection can be made.

(C) Table IID-14. Detection Range as a Function of Figure of Merit (FOM) in dB for Bearing Stake Data[1] and FACT PL9D Model[2] Results. (Station 1B, Run P1, Source Depth = 18m, Receiver Depth = 1685 m, Frequency = 290 Hz)

Data Set	FOM	R_c [3]	Range > R_c
Bearing Stake	75	6.5	
FACT PL9D	75	10	
Bearing Stake	80	8	100% coverage 9 - 10.5 km.
FACT PL9D	80	12.5	
Bearing Stake	85	12	ZDC[4] 70%, 12 - 31 km.
FACT PL9D	85	24	
Bearing Stake	90	29.5	ZDC 35%, 29.5 - 63 km.
FACT PL9D	90	50	
Bearing Stake	95	36	ZDC 80%, 36 - 69 km; ZDC 40%, 69 - 108 km
FACT PL9D	95	70.5	100% coverage 84 - 87.5 km.
Bearing Stake	100	69.5	ZDC 90%, 69.5 - 100 km; ZDC 35%, 100 - 127.5 - 100% coverage 182 - 186 km
FACT PL9D	100	107	100% coverage 121 - 124 km.
Bearing Stake	105	101	ZDC 65%, 101 - 286 km.
FACT PL9D	105	147.5	100% coverage 159.5 - 163.5 km
Bearing Stake	110	204.5	ZDC 90%, 204.5 - 286 km
FACT PL9D	110	188	100% coverage 196.5 - 203 km
Bearing Stake	115	>286	
FACT PL9D	115	250	

1. Smoothed by running average with a 2 kilometer window.

2. Coherent, semicoherent, and incoherent results were identical; no smoothing was used.

3. R_c = Range to which detection coverage is continuous.

4. ZDC = Zonal Detection Coverage in percentage of range interval over which detection can be made.

CONFIDENTIAL

(C) Table IID-15. Detection Range in km as a Function of Figure of Merit (FOM) in dB for Bearing Stake Data[1] and FACT PL9D Model[2] Results.
(Station 1B, Run P1, Source Depth = 18m, Receiver Depth = 3320 m, Frequency = 290 Hz)

Data Set	FOM	R_c[3]	Range $> R_c$
Bearing Stake	75	8	
FACT PL9D	75	11	100% coverage 19 - 20 km.
Bearing Stake	80	11	100% coverage 12 - 14 km.
FACT PL9D	80	21	
Bearing Stake	85	18.5	100% coverage 27 - 31.5 km
FACT PL9D	85	22.5	100% coverage 55 - 57 km.
Bearing Stake	90	18.5	ZDC[4] 45%, 18.5 - 56 km
FACT PL9D	90	59.5	
Bearing Stake	95	22	ZDC 75%, 22 - 75; ZDC 20%, 75 - 133 km
FACT PL9D	95	63	100% coverage 72.5 - 99 km
Bearing Stake	100	25	ZDC 70%, 25 - 163 km; ZDC 26%, 163 - 238 km
FACT PL9D	100	102.5	100% coverage 130 - 138 km.
Bearing Stake	105	79	100% coverage (with exception of 79 - 81 and 134-135) to 141 km; ZDC 35%, 141 - 252 km.
FACT PL9D	105	142.5	100% coverage 167 - 178 km.
Bearing Stake	110	141.5	100% coverage (except for 5 dropouts) to>286 km.
FACT PL9D	110	183	100% coverage 194 - 219.5 km.

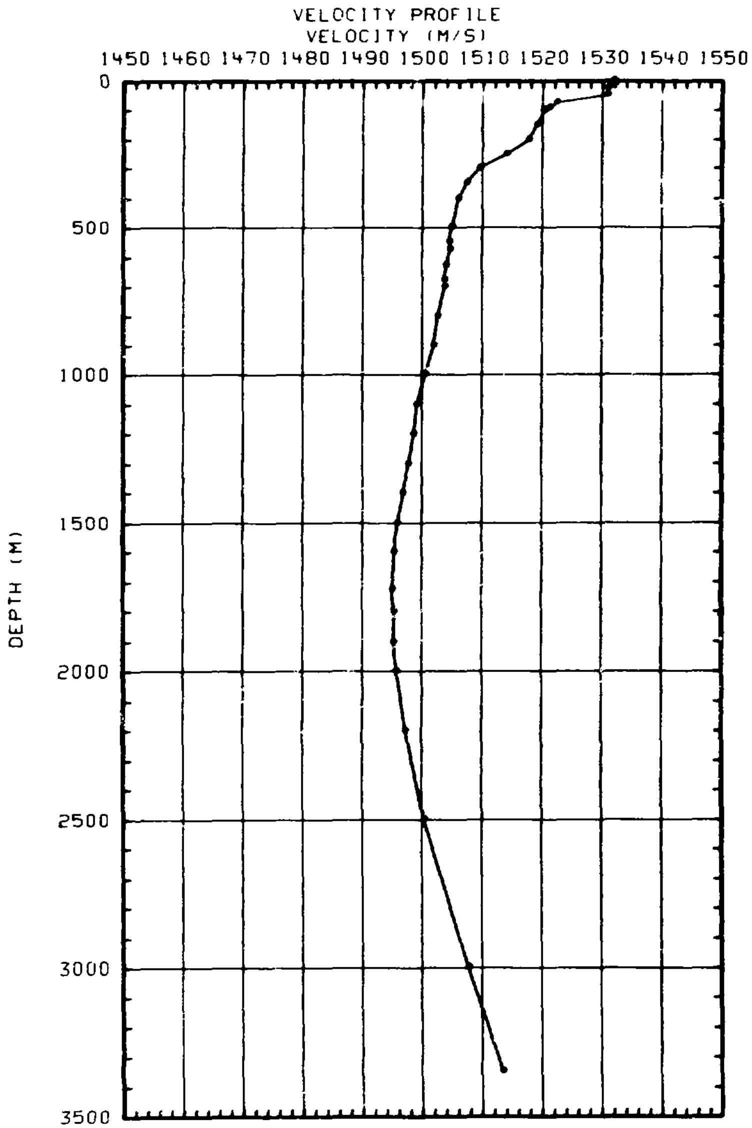
1. Smoothed by running average with a 2-kilometer window.
2. Coherent, semicoherent, and incoherent results were identical; no smoothing was used.
3. R_c = Range to which detection coverage is continuous.
4. ZDC = Zonal Detection Coverage in percentage of range interval over which detection can be made.

CONFIDENTIAL

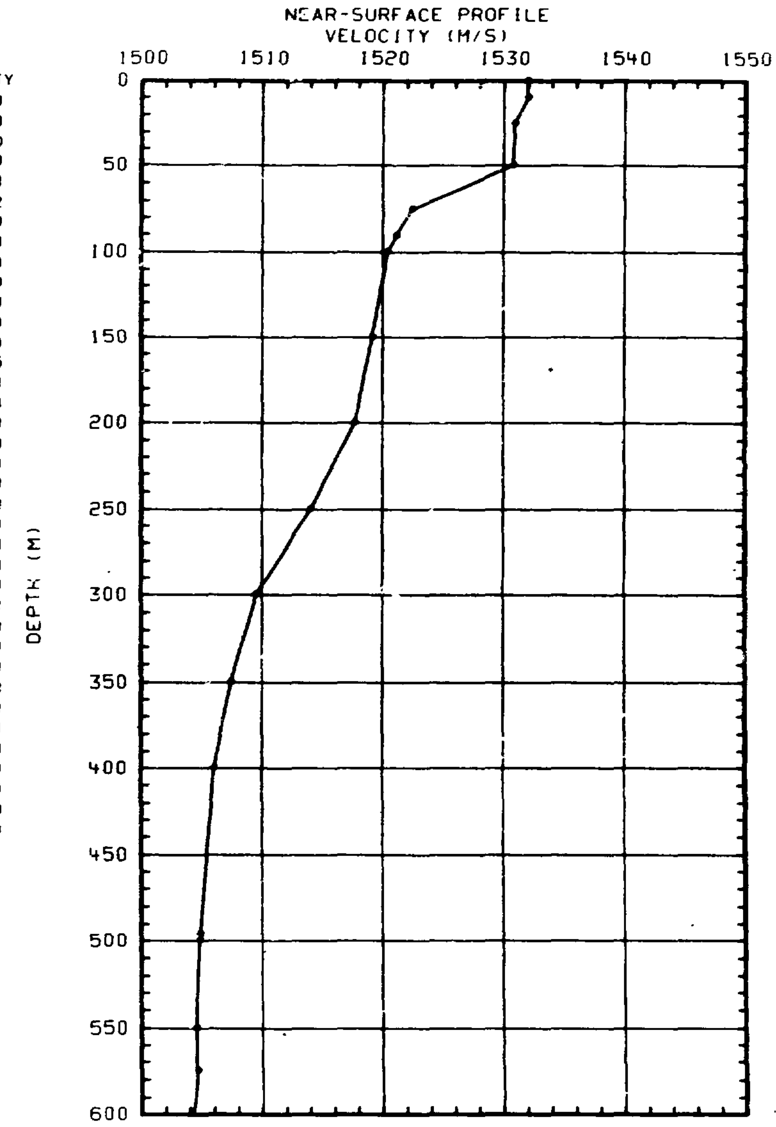
(C) Table IID-16. Detection Range in km as a Function of Figure of Merit (FOM) in dB for Bearing Stake Data[1] and FACT PL9D Model[2] Results. (Station 1B, Run P1, Source Depth = 18m, Receiver Depth = 3350 m, Frequency = 290 Hz)

Data Set	FOM	R_c [3]	Range > R_c
Bearing Stake	75	5.5	
FACT PL9D	75	12	100% coverage 19 - 20 km
Bearing Stake	80	8	ZDC[4] 80%, 8 - 19 km.
FACT PL9D	80	21	
Bearing Stake	85	13.5	100% coverage 16 - 19 km.
FACT PL9D	85	23	100% coverage 56 - 58 km.
Bearing Stake	90	14	ZDC 45%, 14 - 58 km
FACT PL9D	90	59	
Bearing Stake	95	24	ZDC 75%, 24 - 63 km; ZDC 40%, 63 - 112 km.
FACT PL9D	95	63	100% coverage, 68 - 98 km
Bearing Stake	100	36.5	ZDC 85%, 36.5 - 134 km; ZDC 15%, 134 - 222 km
FACT PL9D	100	102	100% coverage 130 - 137.5 km.
Bearing Stake	105	134	ZDC 70%, 134 - 286 km.
FACT PL9D	105	143	100% coverage 162 - 179 km.
Bearing Stake	110	257	ZDC 85%, 257 - 286 km.
FACT PL9D	110	183.5	100% coverage 194 - 219 and 242.5 - 245.5 km.

1. Smoothed by running average with a 2-kilometer window.
2. Coherent, semicoherent and incoherent runs were identical; no smoothing was used.
3. R_c = Range to which detection coverage is continuous.
4. ZDC = Zonal Detection Coverage in percentage of range interval over which detection can be made.

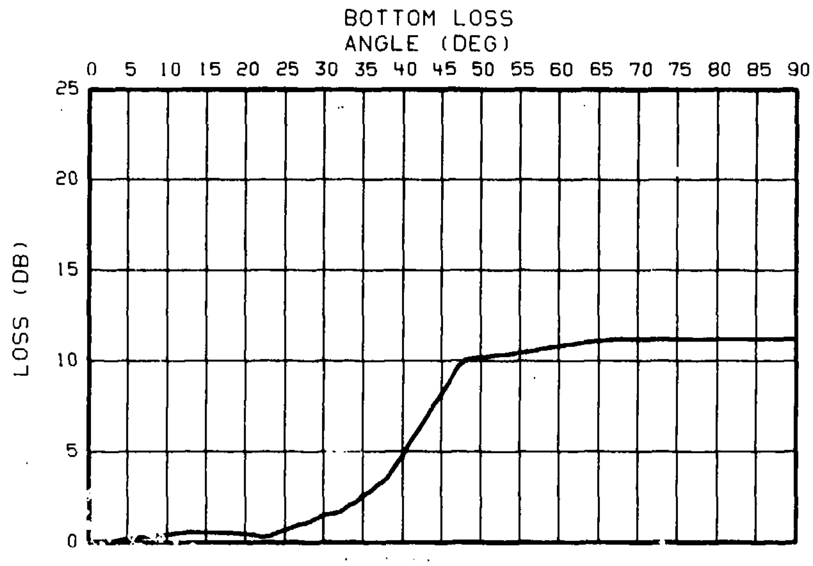


DEPTH	VELOCITY
0.0	1531.90
10.0	1532.00
25.0	1530.90
50.0	1530.80
75.0	1522.40
91.0	1521.12
100.0	1520.40
150.0	1519.10
200.0	1517.70
250.0	1514.00
300.0	1509.50
350.0	1507.40
400.0	1506.00
496.0	1504.85
500.0	1504.80
550.0	1504.50
575.0	1504.60
625.0	1504.00
675.0	1503.60
700.0	1503.70
800.0	1502.60
900.0	1501.90
1000.0	1500.50
1100.0	1499.10
1200.0	1498.60
1300.0	1497.70
1400.0	1496.80
1500.0	1495.90
1600.0	1495.30
1725.0	1495.00
1800.0	1495.30
1901.0	1495.20
2000.0	1495.70
2200.0	1497.20
2500.0	1500.30
3000.0	1507.70
3350.0	1513.50



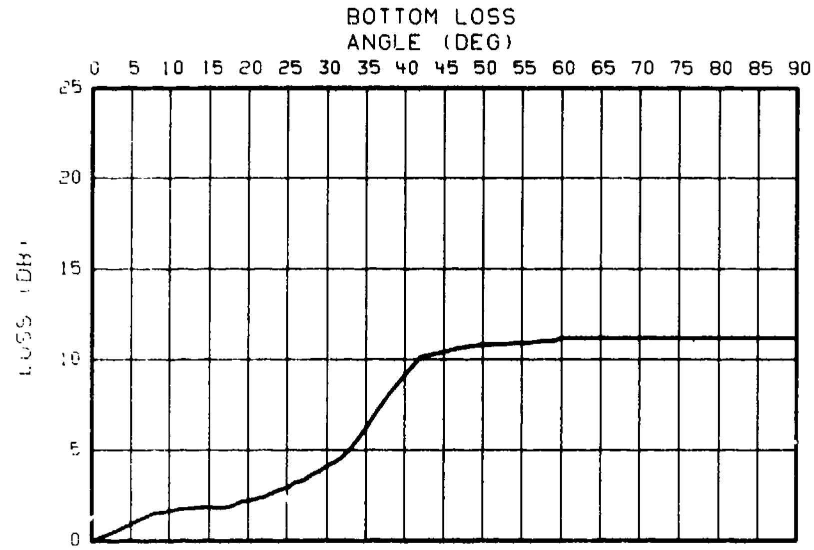
CONFIDENTIAL

(U) Figure IID-1. Bearing Stake Sound Speed Profile Station 1B, Run P1



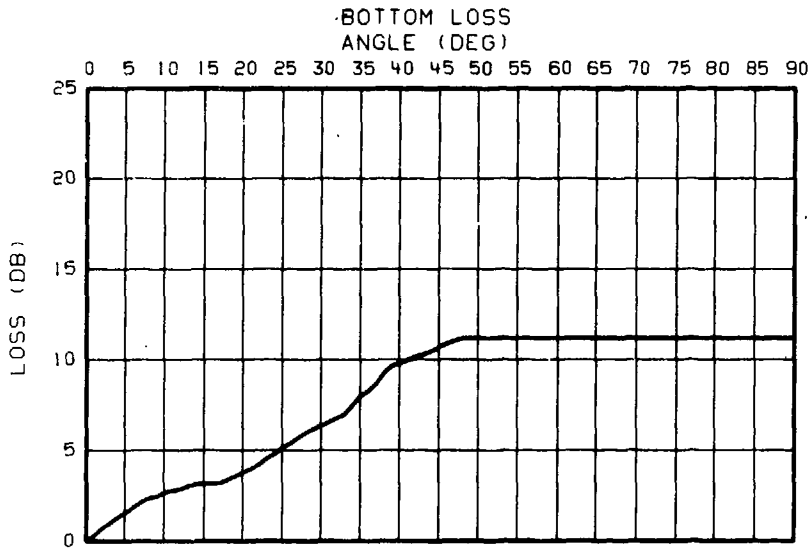
CONFIDENTIAL

(C) Figure IID-2. Bottom Loss Versus Grazing Angle. Frequency = 25 Hertz



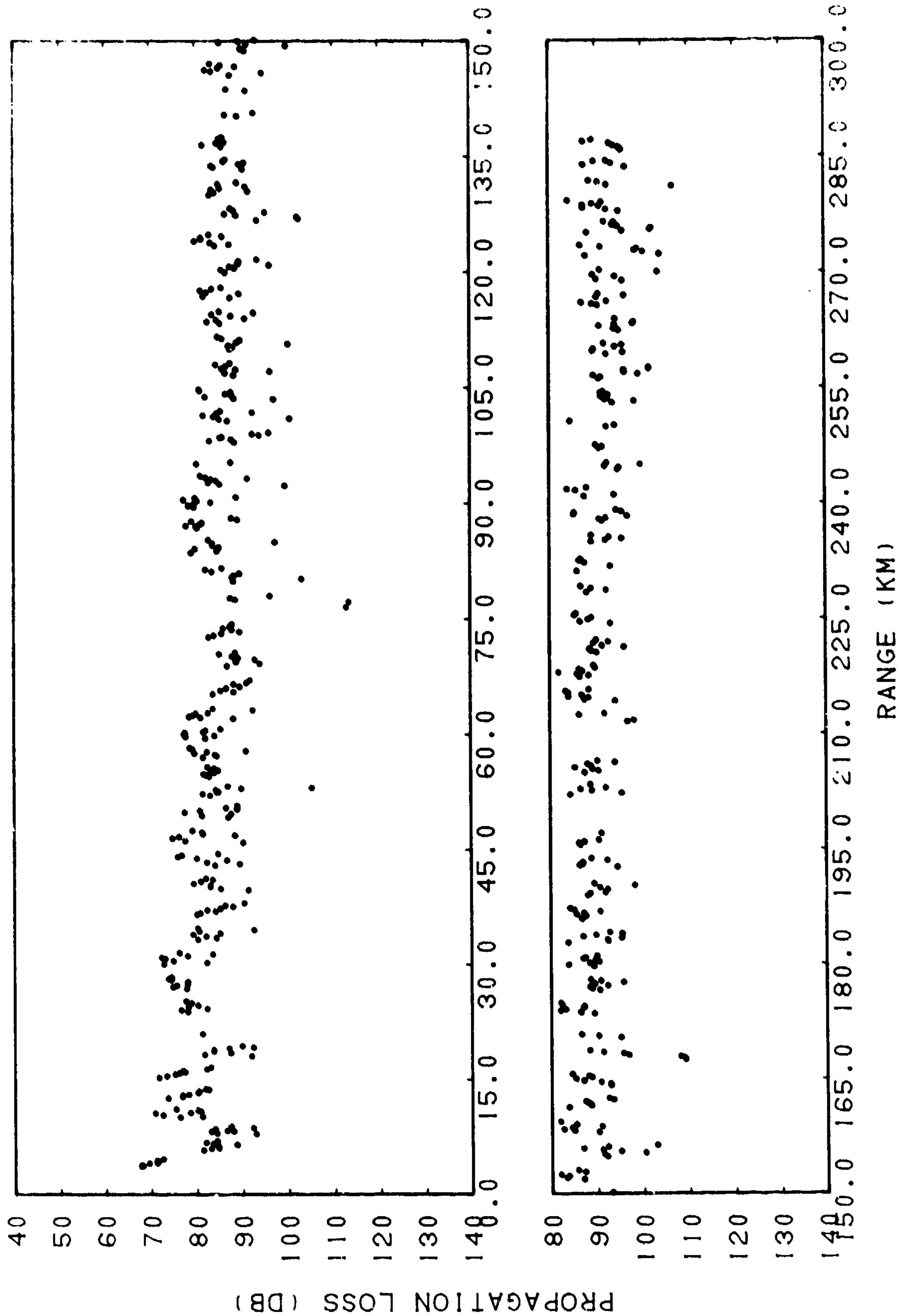
CONFIDENTIAL

(C) Figure IID-3. Bottom Loss Versus Grazing Angle. Frequency = 140 Hertz



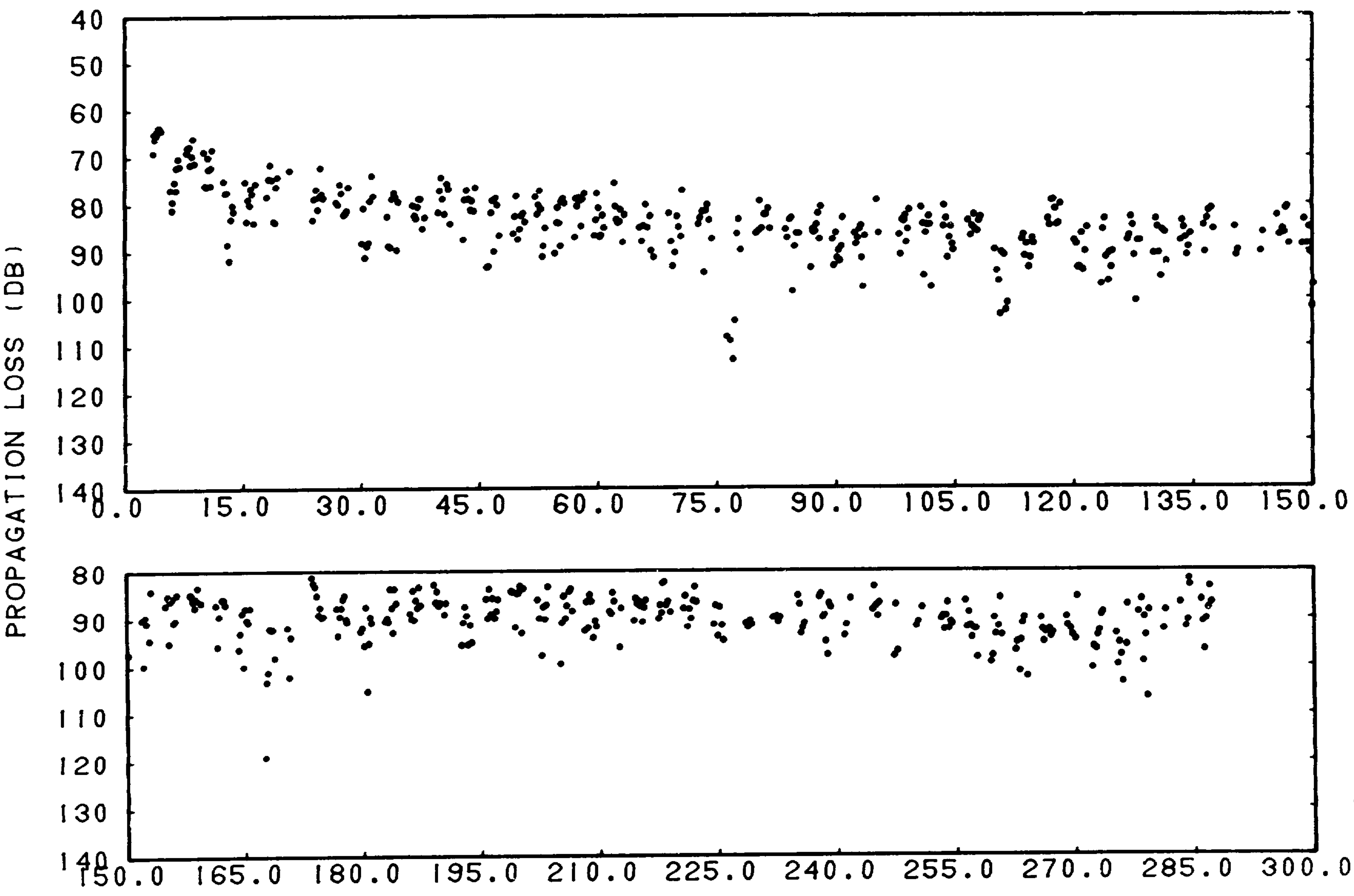
CONFIDENTIAL

(C) Figure IID-4. Bottom Loss Versus Grazing Angle. Frequency = 290 Hertz



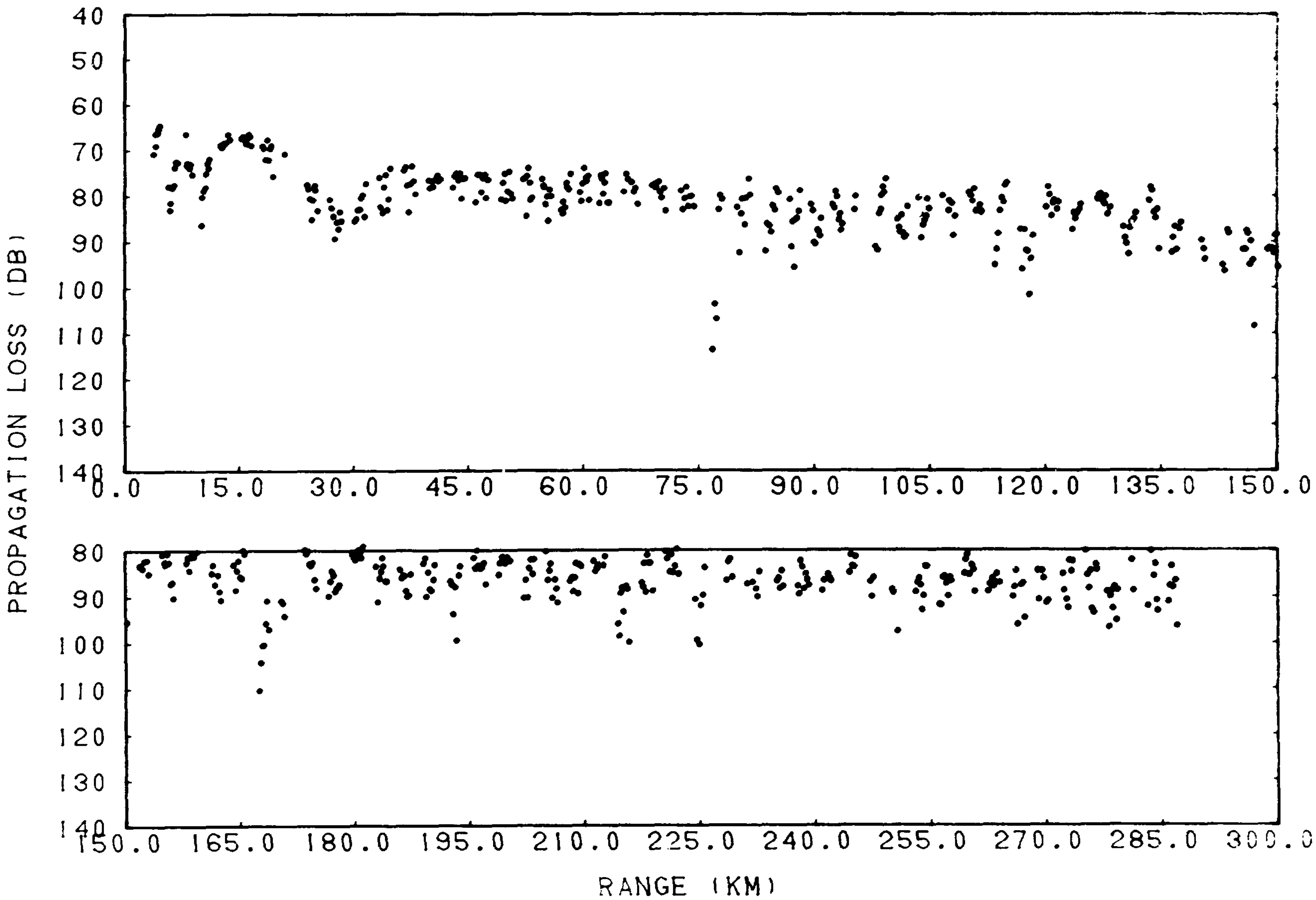
CONFIDENTIAL

(C) Figure IID-5. Bearing Stake Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 496 Meters, Frequency = 25 Hertz



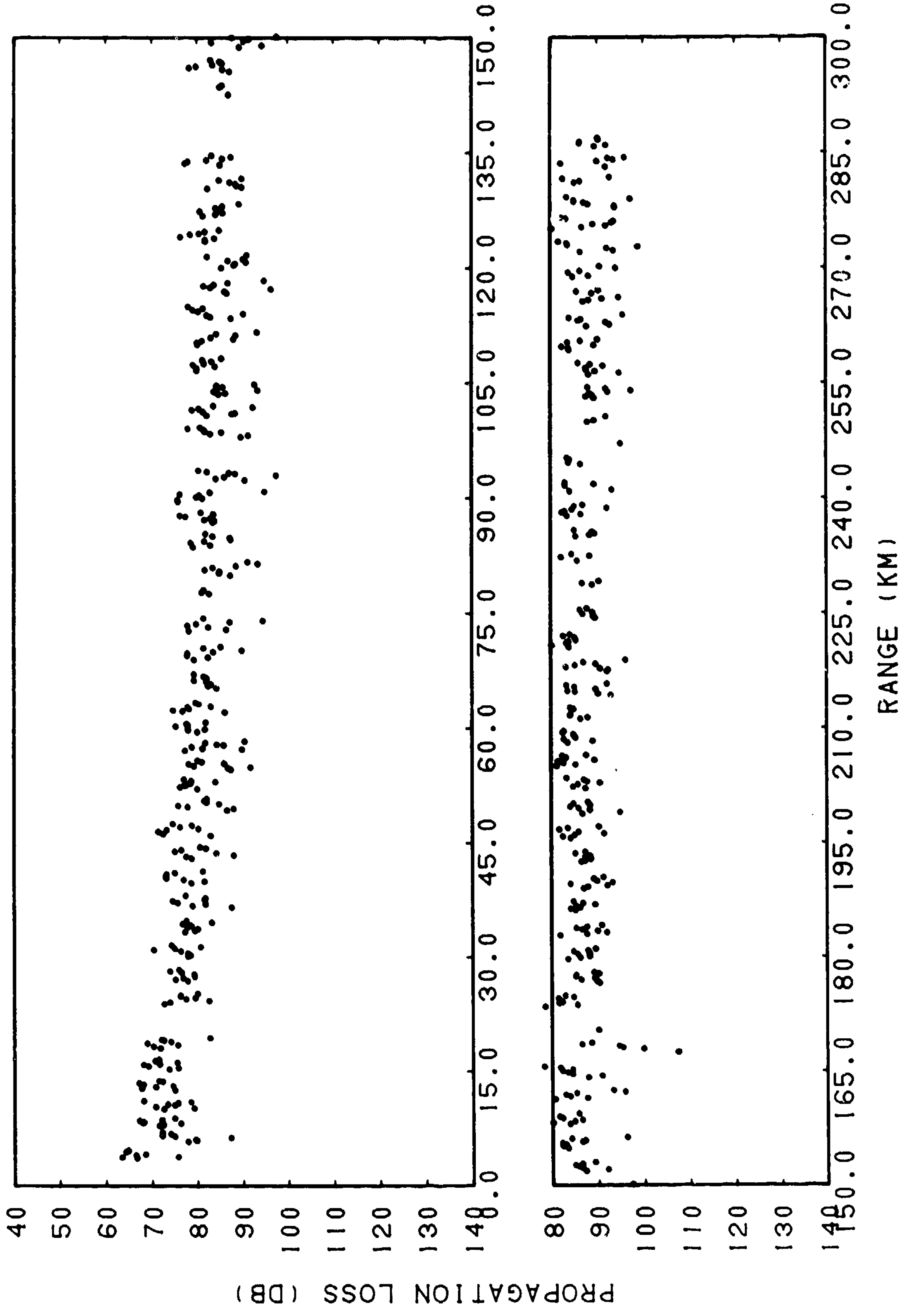
CONFIDENTIAL

(C) Figure IID-6. Bearing Stake Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 1685 Meters, Frequency = 25 Hertz



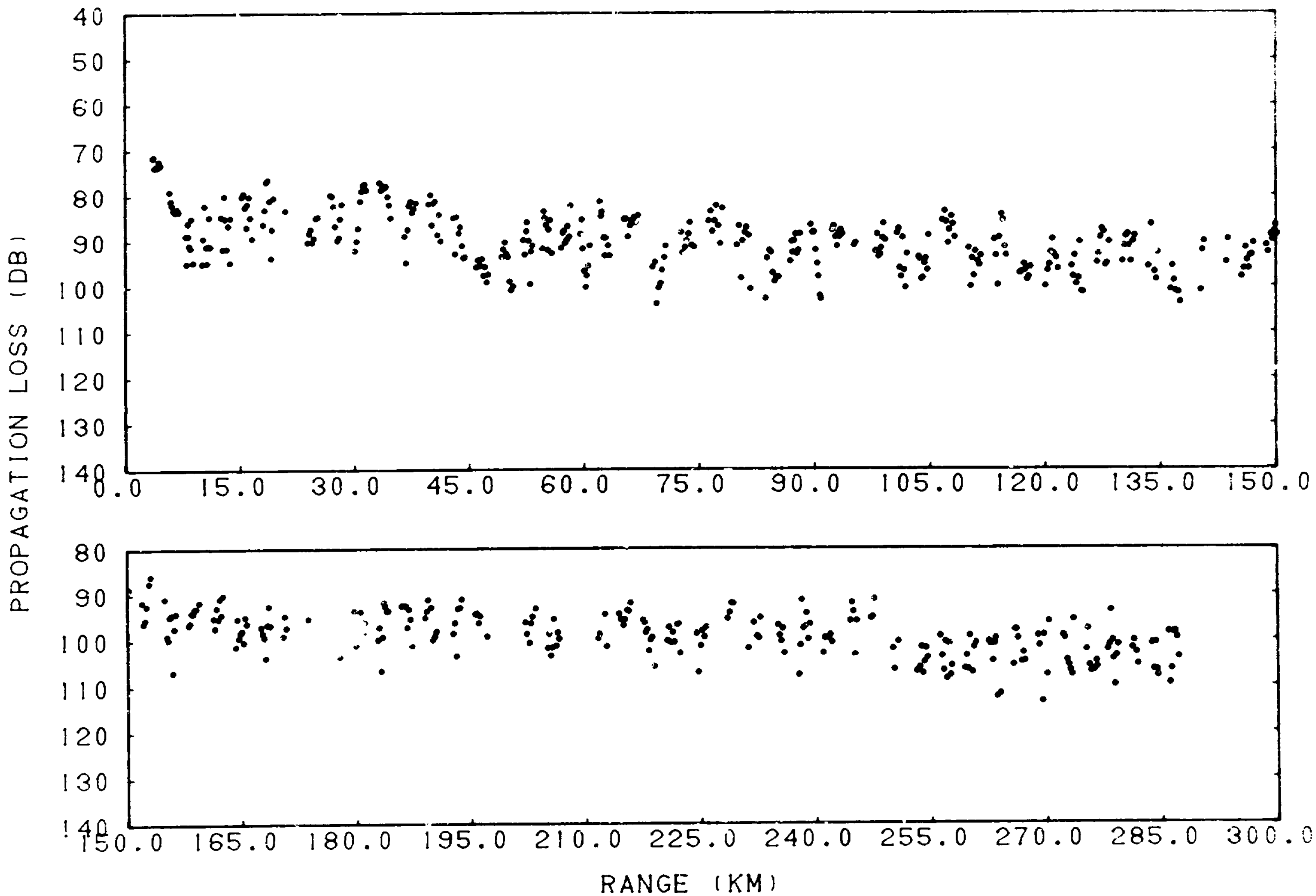
CONFIDENTIAL

(C) Figure IID-7. Bearing Stake Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 3320 Meters, Frequency = 25 Hertz



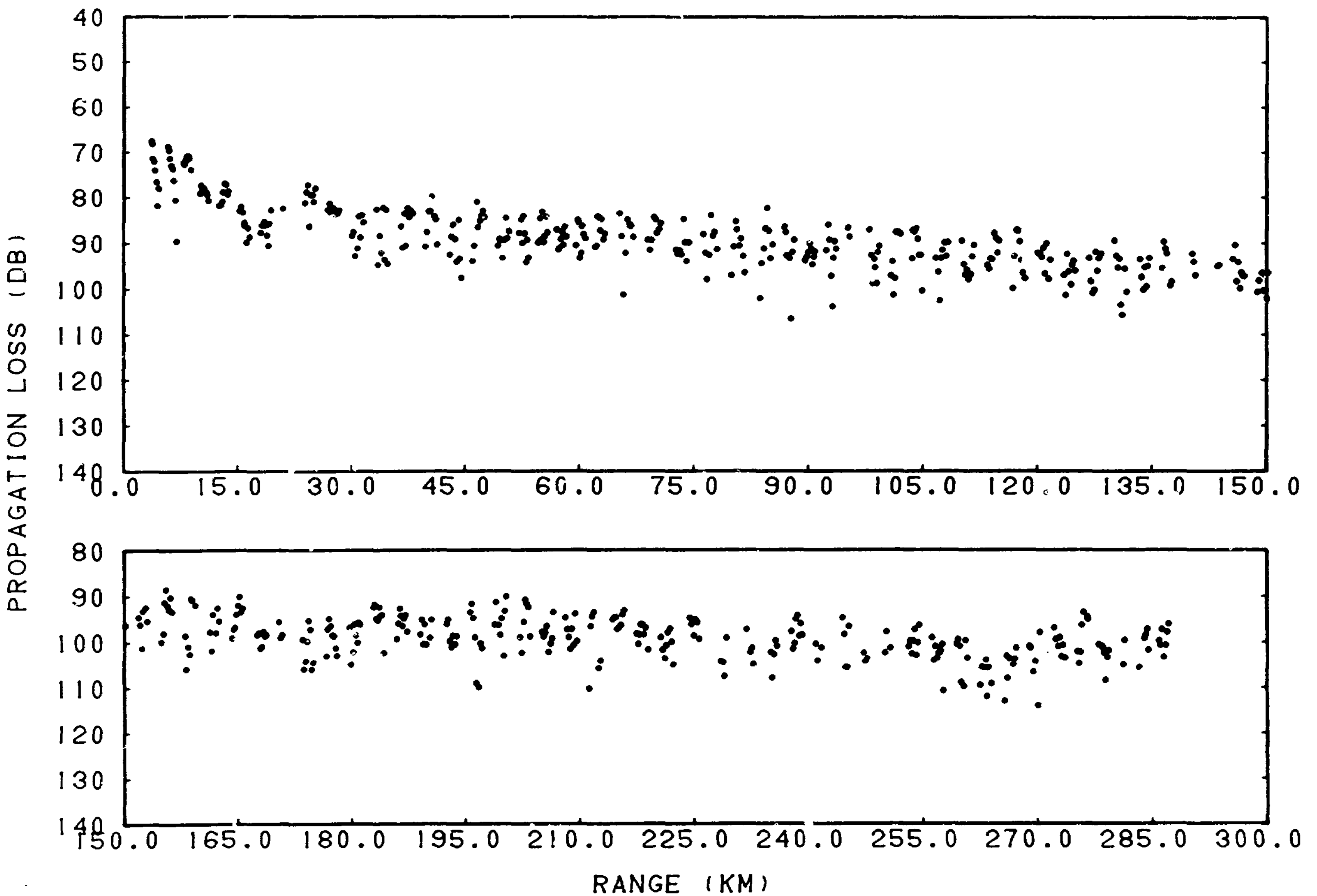
CONFIDENTIAL

(C) Figure IID-8. Bearing Stake Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 3350 Meters, Frequency = 25 Hertz



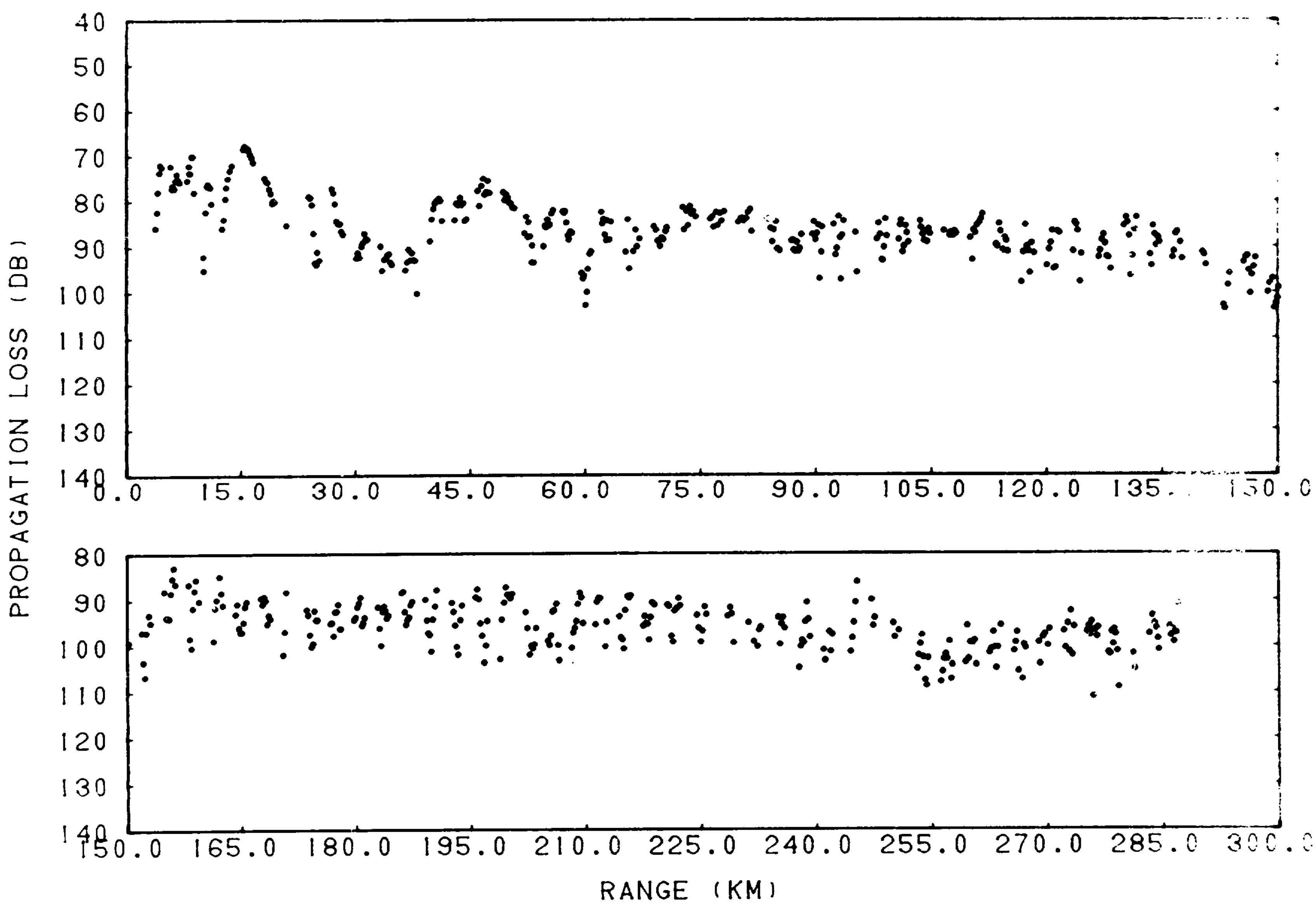
CONFIDENTIAL

(C) Figure IID-9. Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 496 Meters, Frequency = 140 Hertz



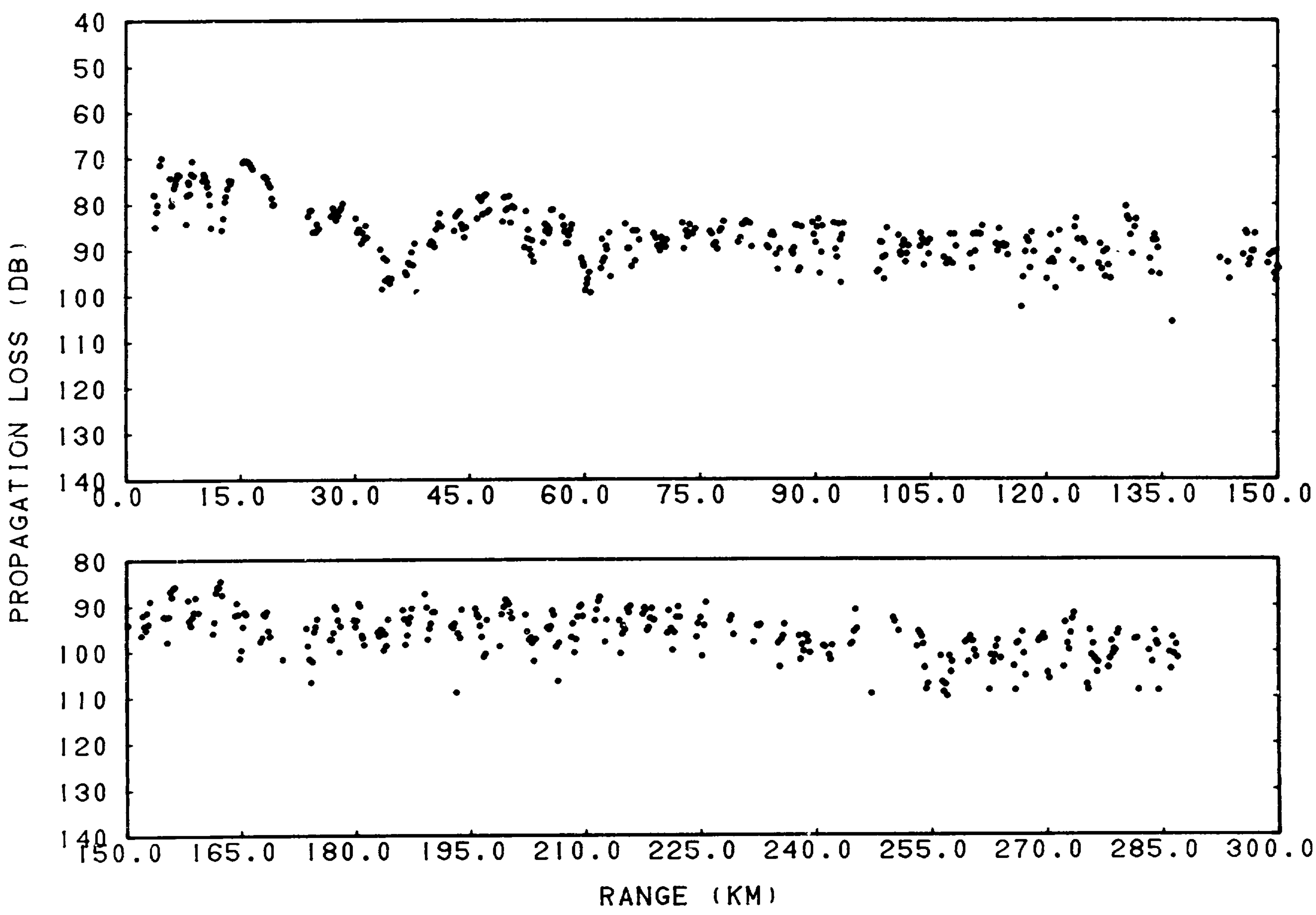
CONFIDENTIAL

(C) Figure IID-10. Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 1685 Meters, Frequency = 140 Hertz



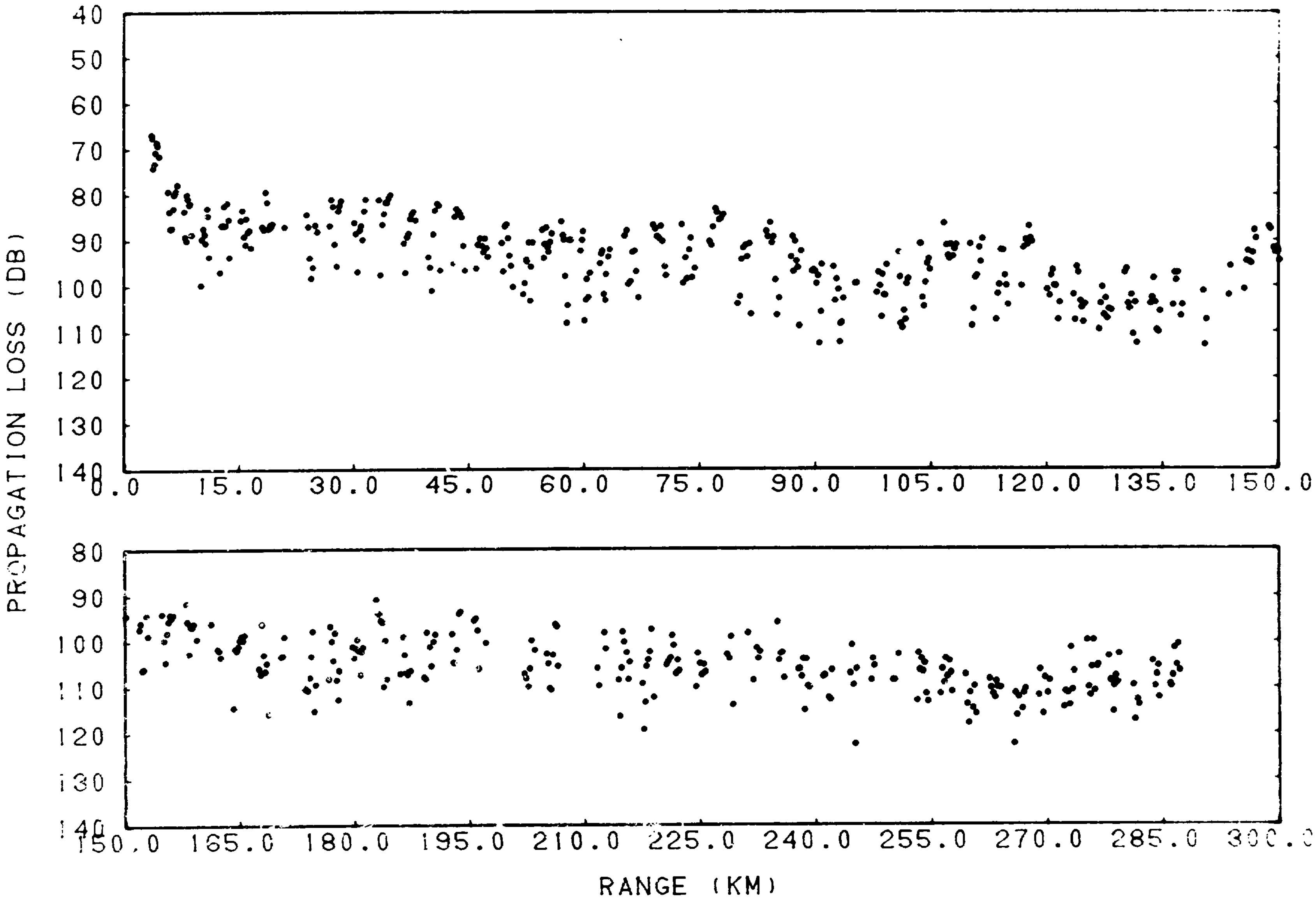
CONFIDENTIAL

(C) Figure IID-11. Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3320 Meters, Frequency = 140 Hertz



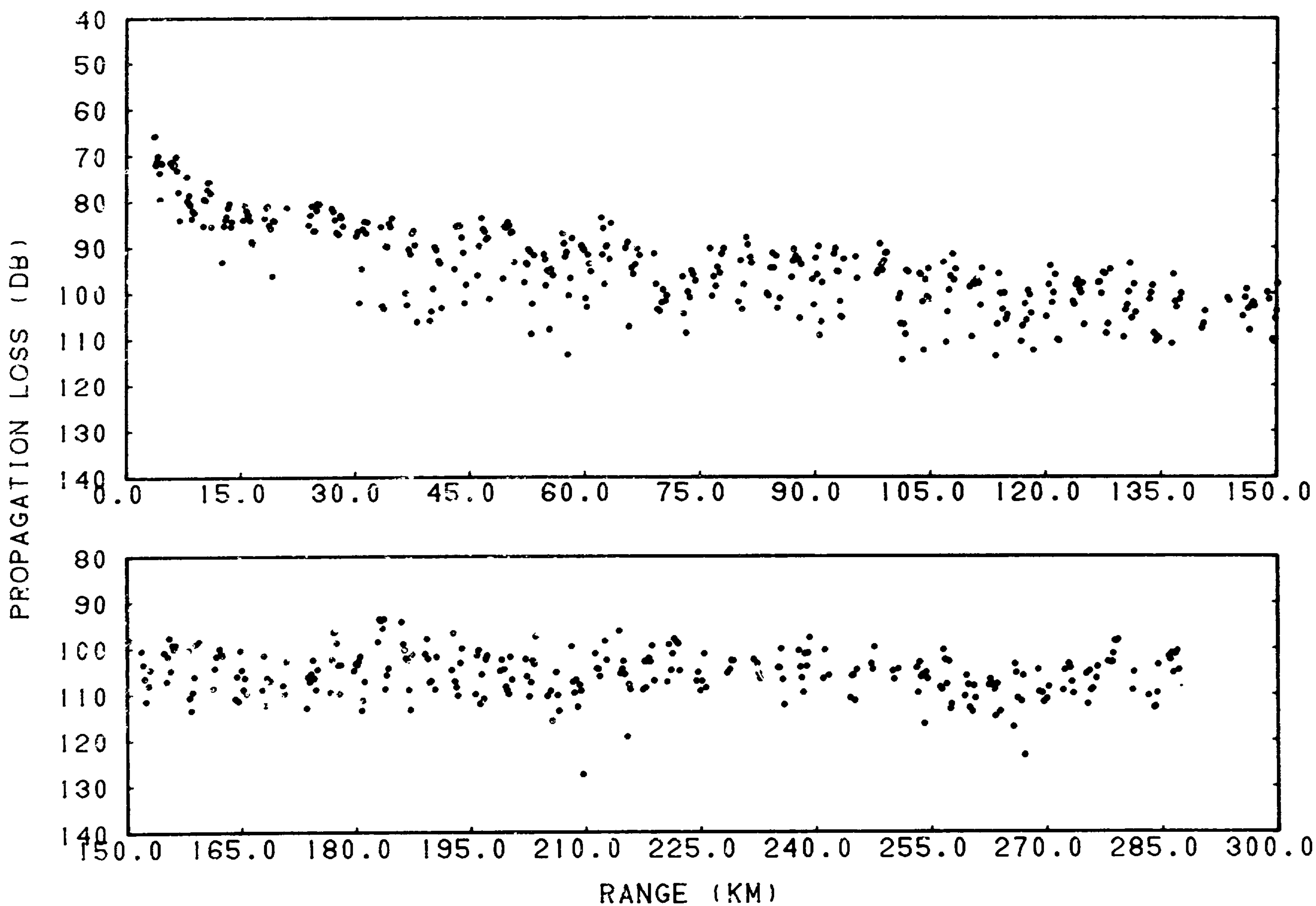
CONFIDENTIAL

(C) Figure IID-12. Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3350 Meters, Frequency = 140 Hertz



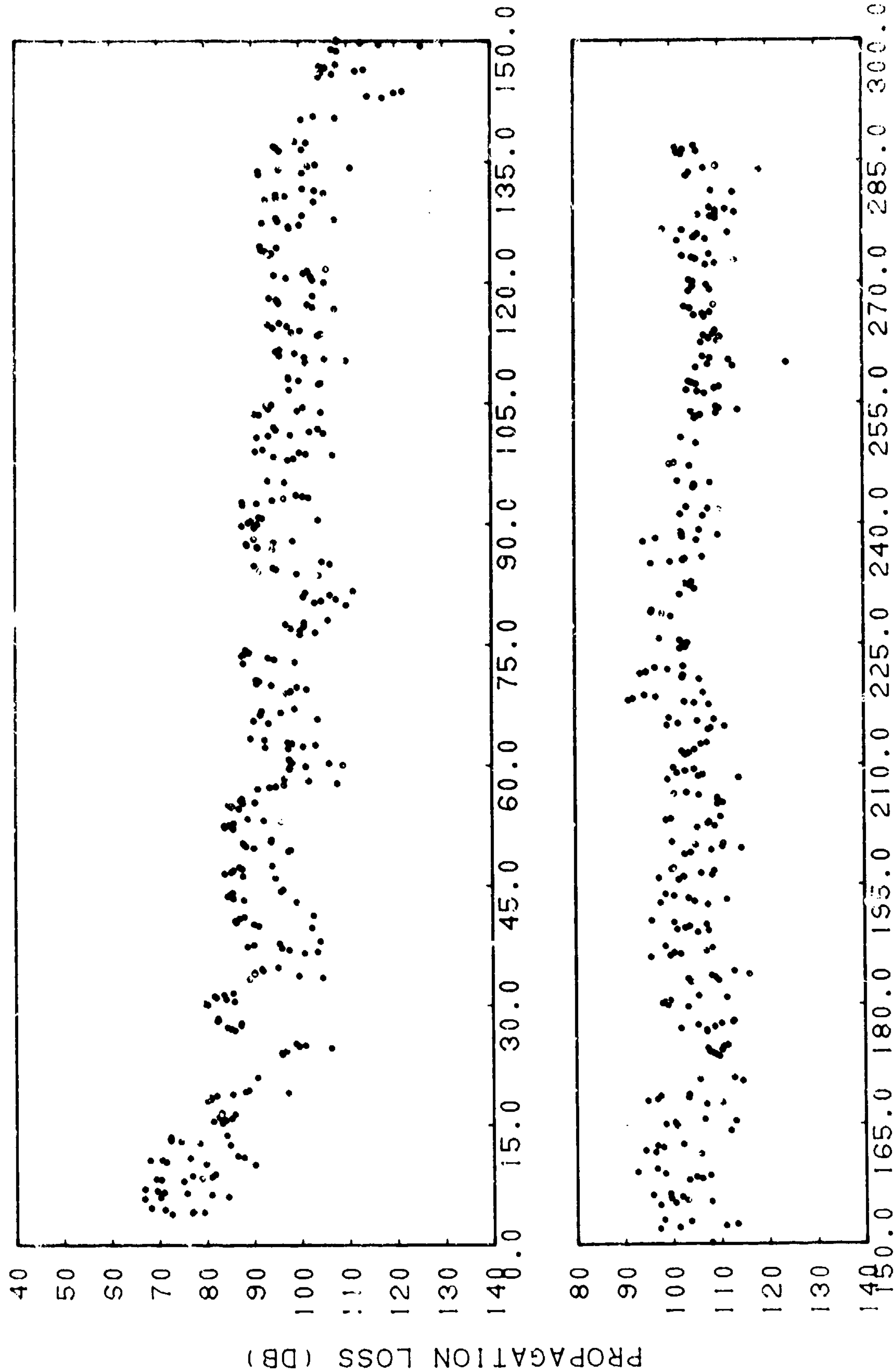
CONFIDENTIAL

(C) Figure IID-13. Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 496 Meters, Frequency = 290 Hertz



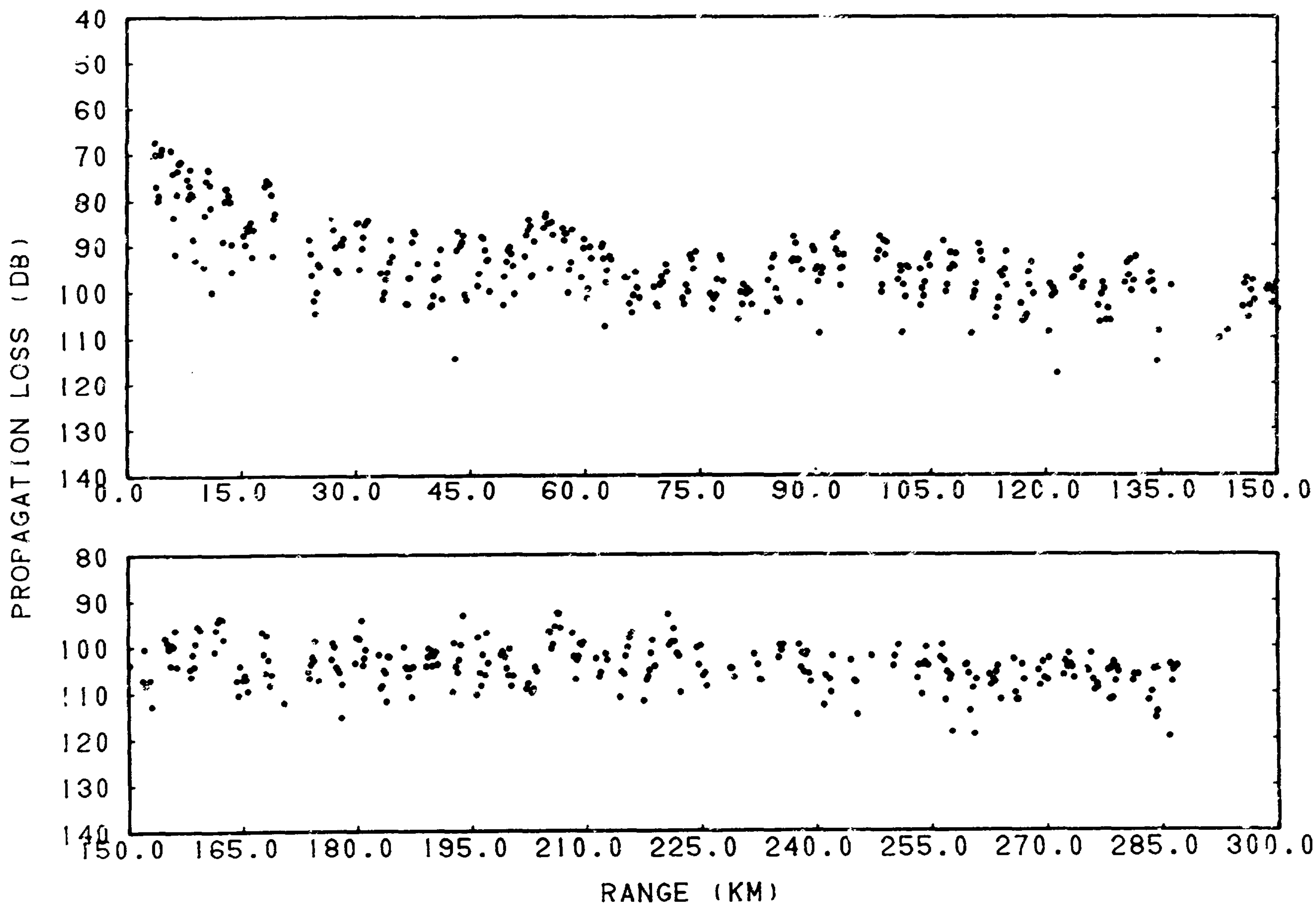
CONFIDENTIAL

(C) Figure IID-14. Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 1685 Meters, Frequency = 290 Hertz



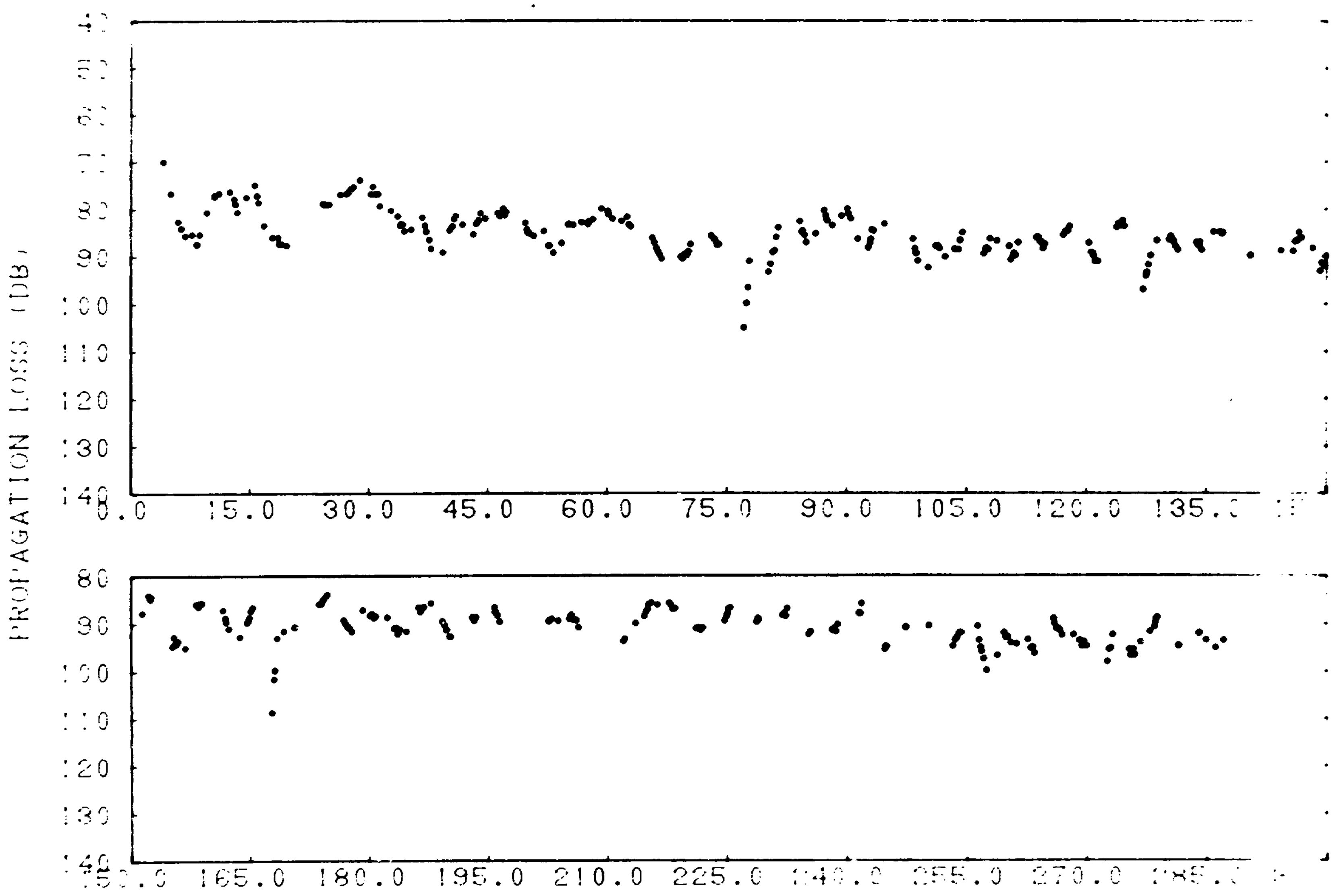
CONFIDENTIAL

(C) Figure IID-15. Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3320 Meters, Frequency = 290 Hertz



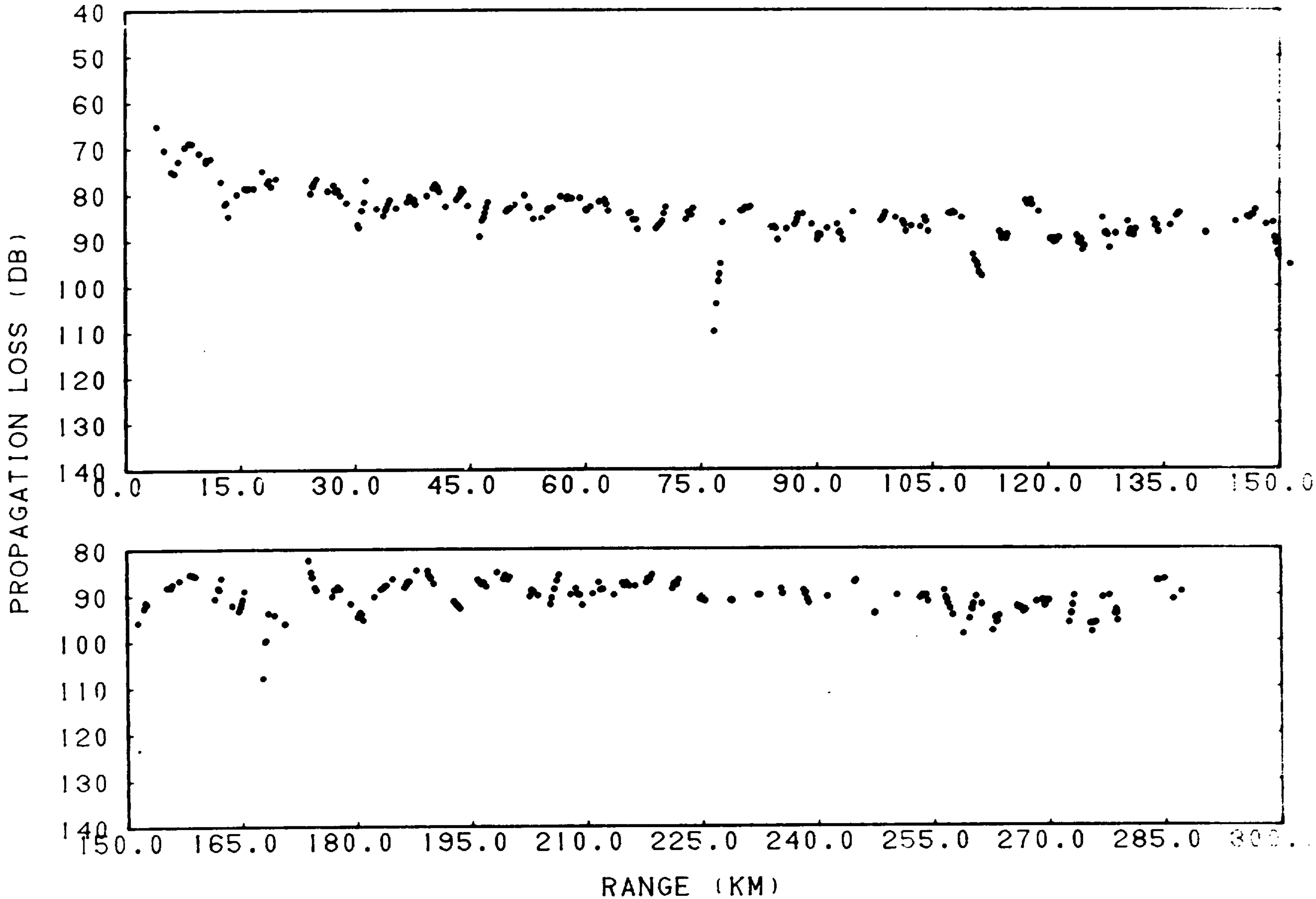
CONFIDENTIAL

(C) Figure IID-16. Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3350 Meters, Frequency = 290 Hertz



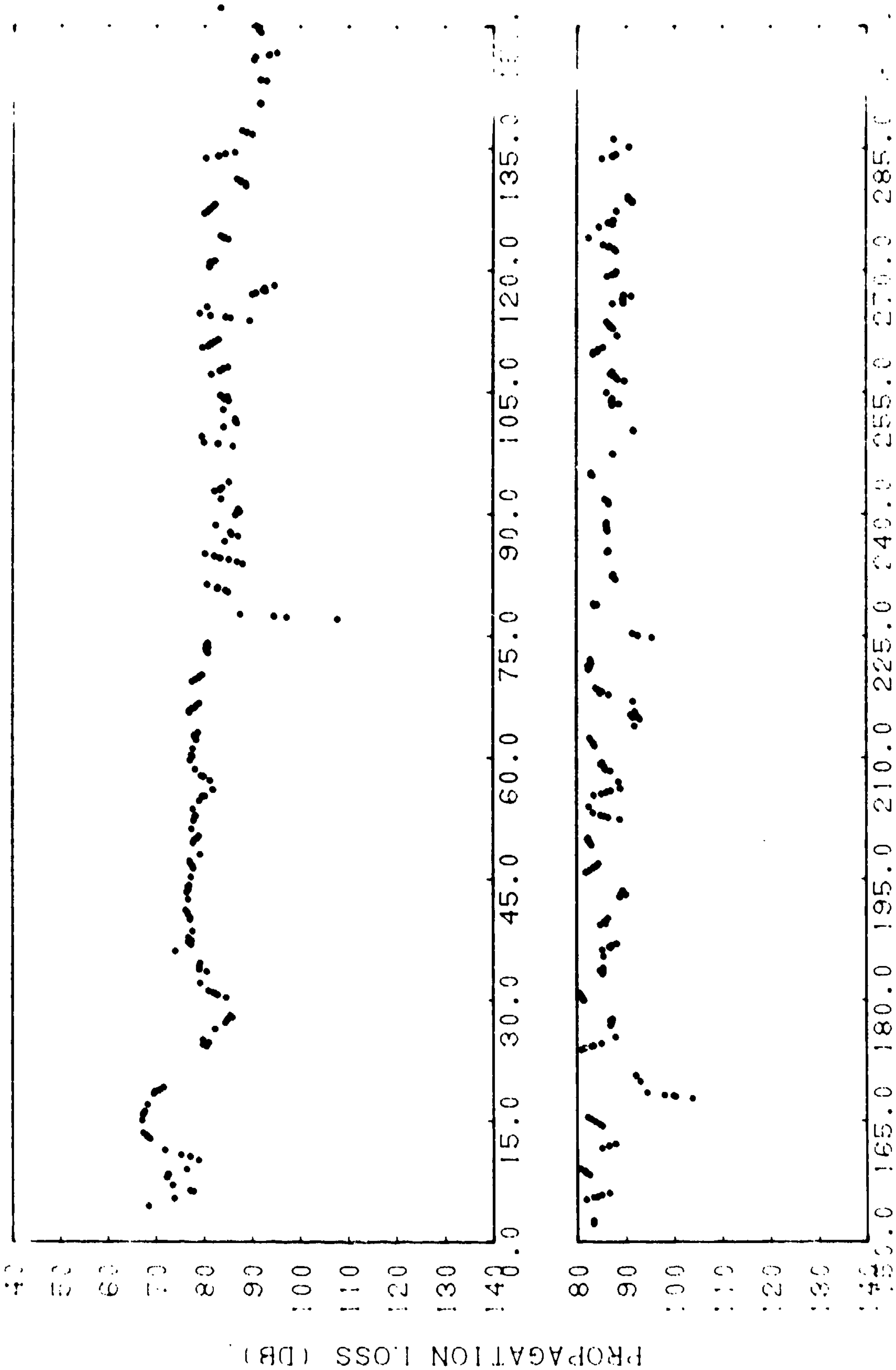
CONFIDENTIAL

(C) Figure IID-17. Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 496 Meters, Frequency = 25 Hertz

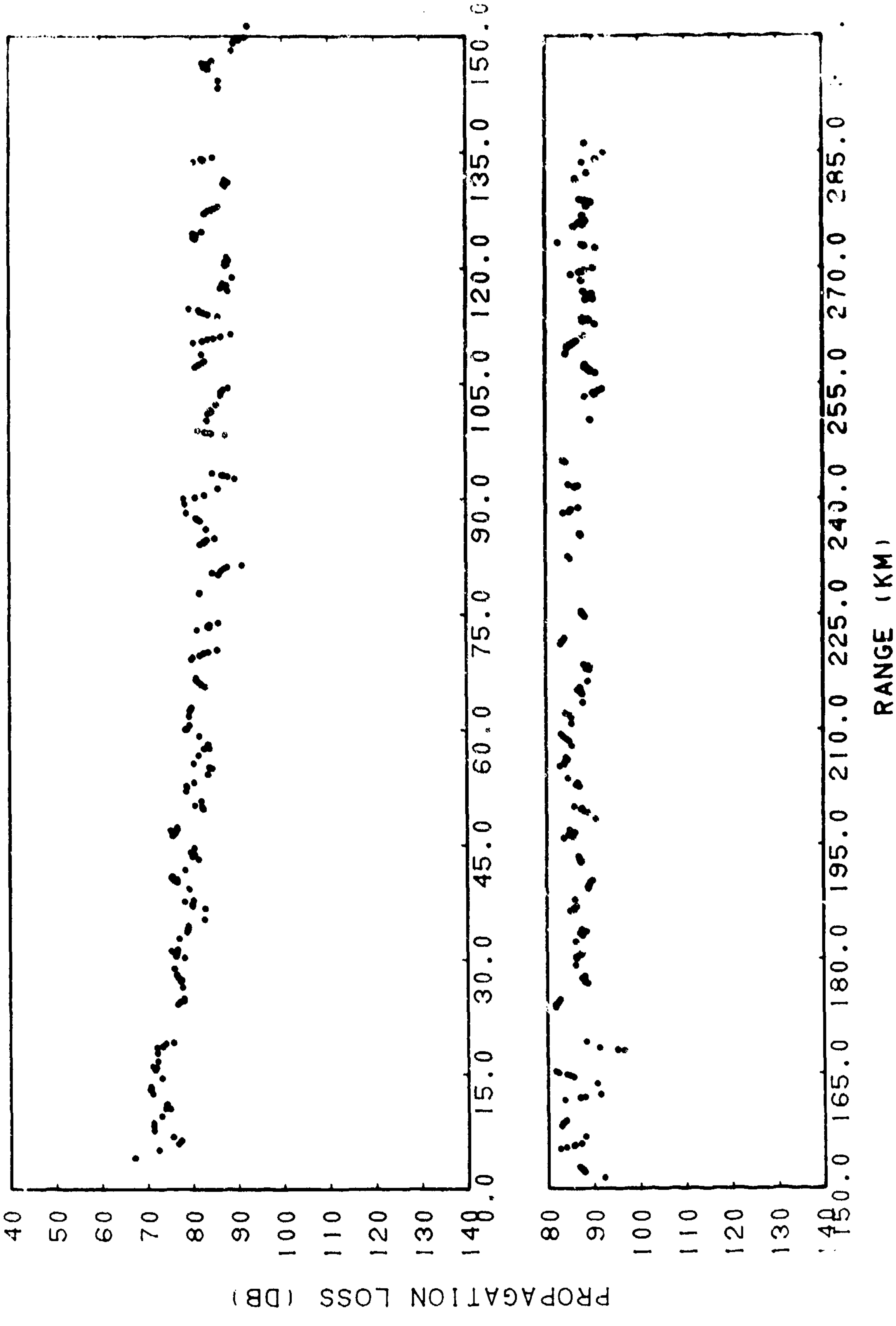


CONFIDENTIAL

(C) Figure IID-18. Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 1685 Meters, Frequency = 25 Hertz

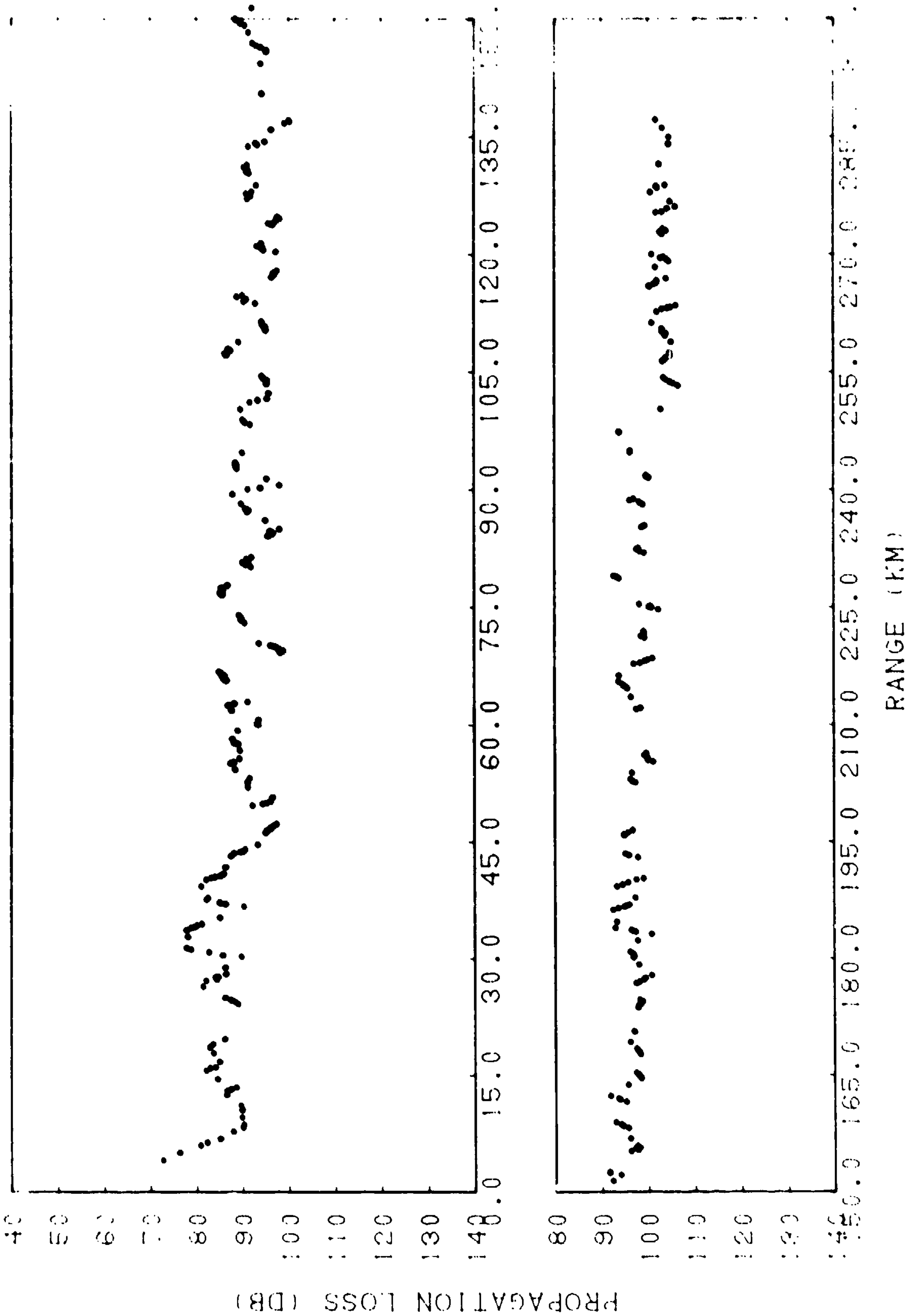


(C) Figure IID-19. Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 3320 Meters, Frequency = 25 Hertz



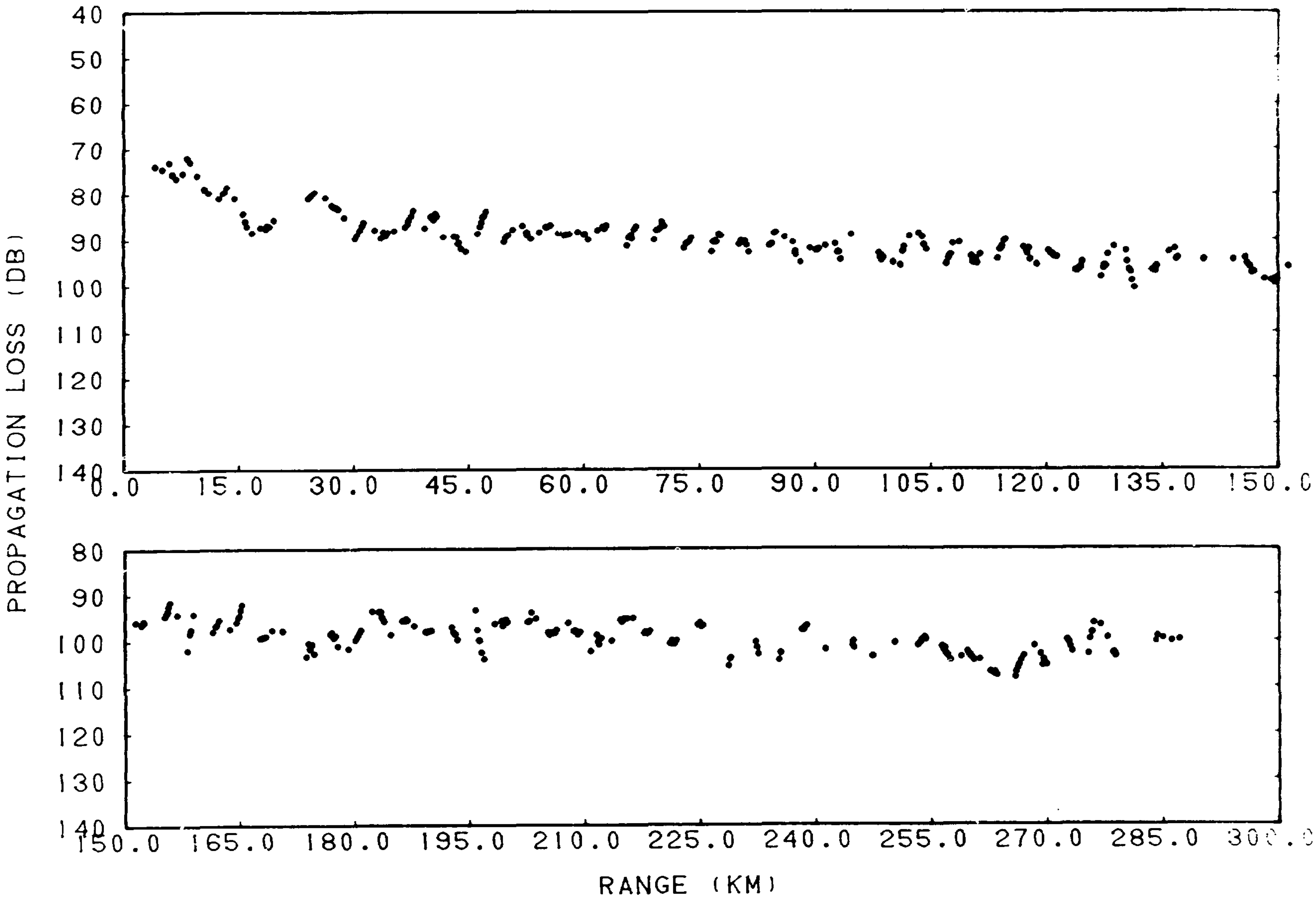
CONFIDENTIAL

(C) Figure IID-20. Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 3350 Meters, Frequency = 25 Hertz



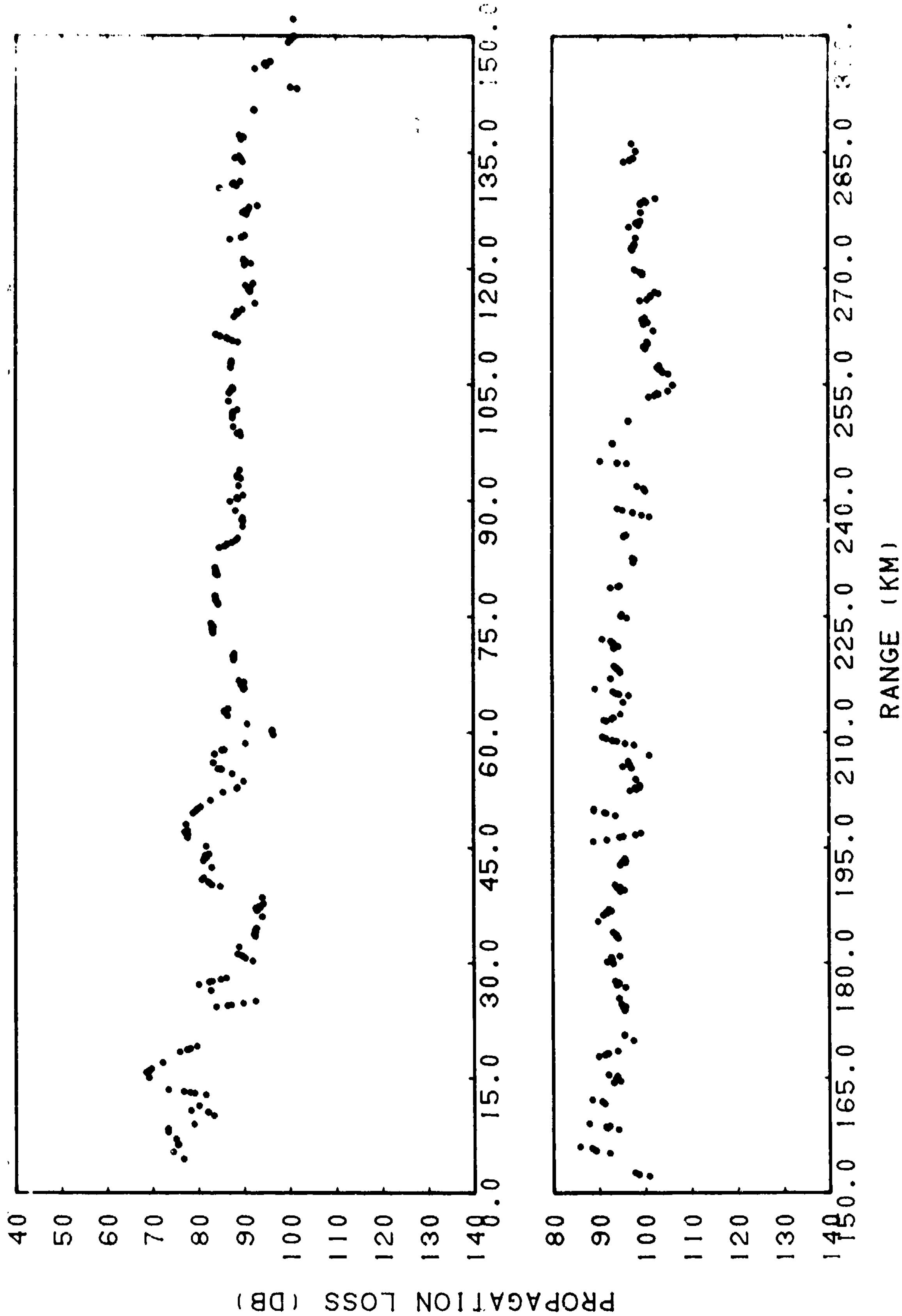
CONFIDENTIAL

(C) Figure IID-21. Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 496 Meters, Frequency = 140 Hertz



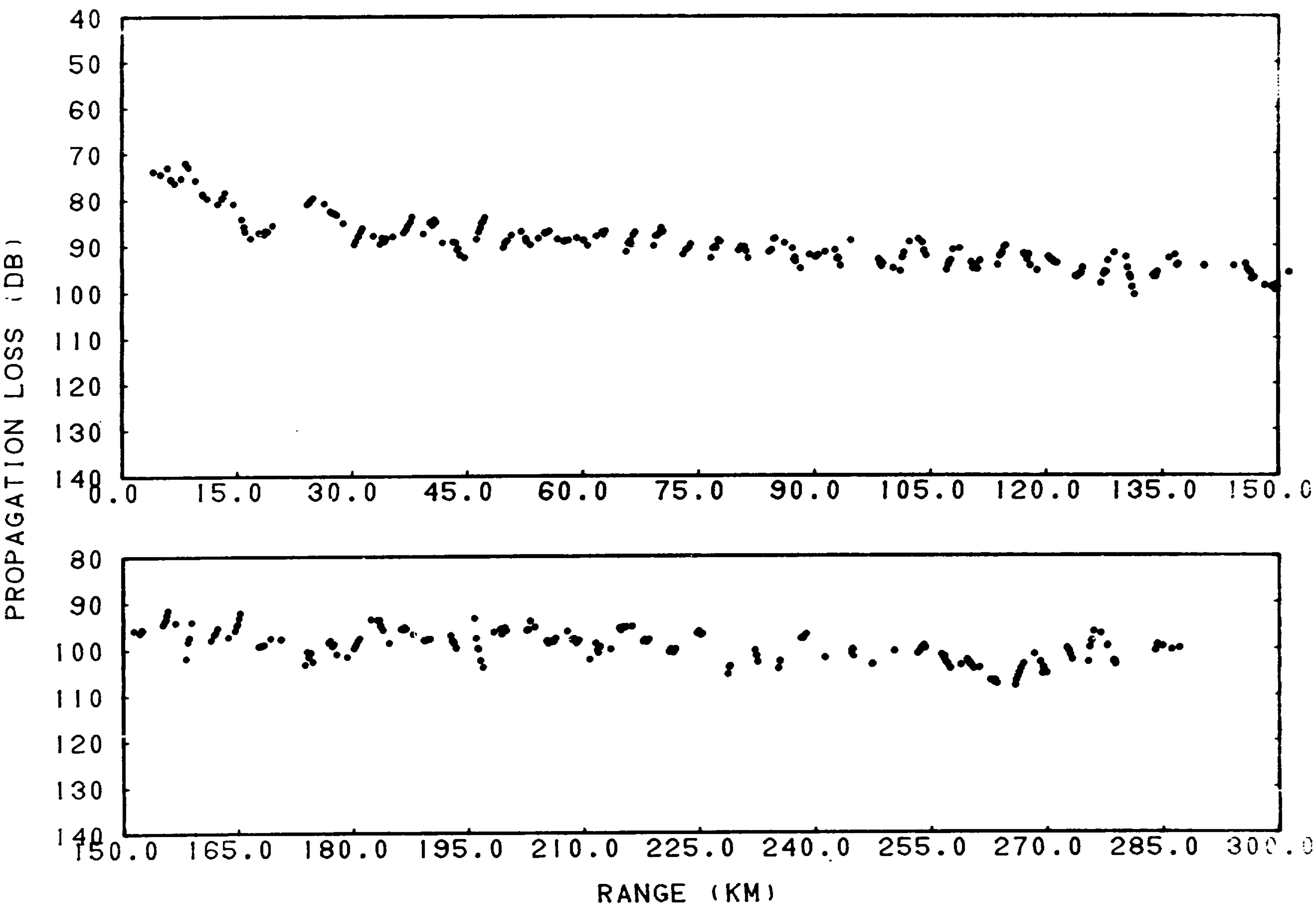
CONFIDENTIAL

(C) Figure IID-22. Smoothed Bearing Stake Station 1B, Run 21, Source Depth = 18 Meters, Receiver Depth = 1685 Meters, Frequency = 140 Hertz



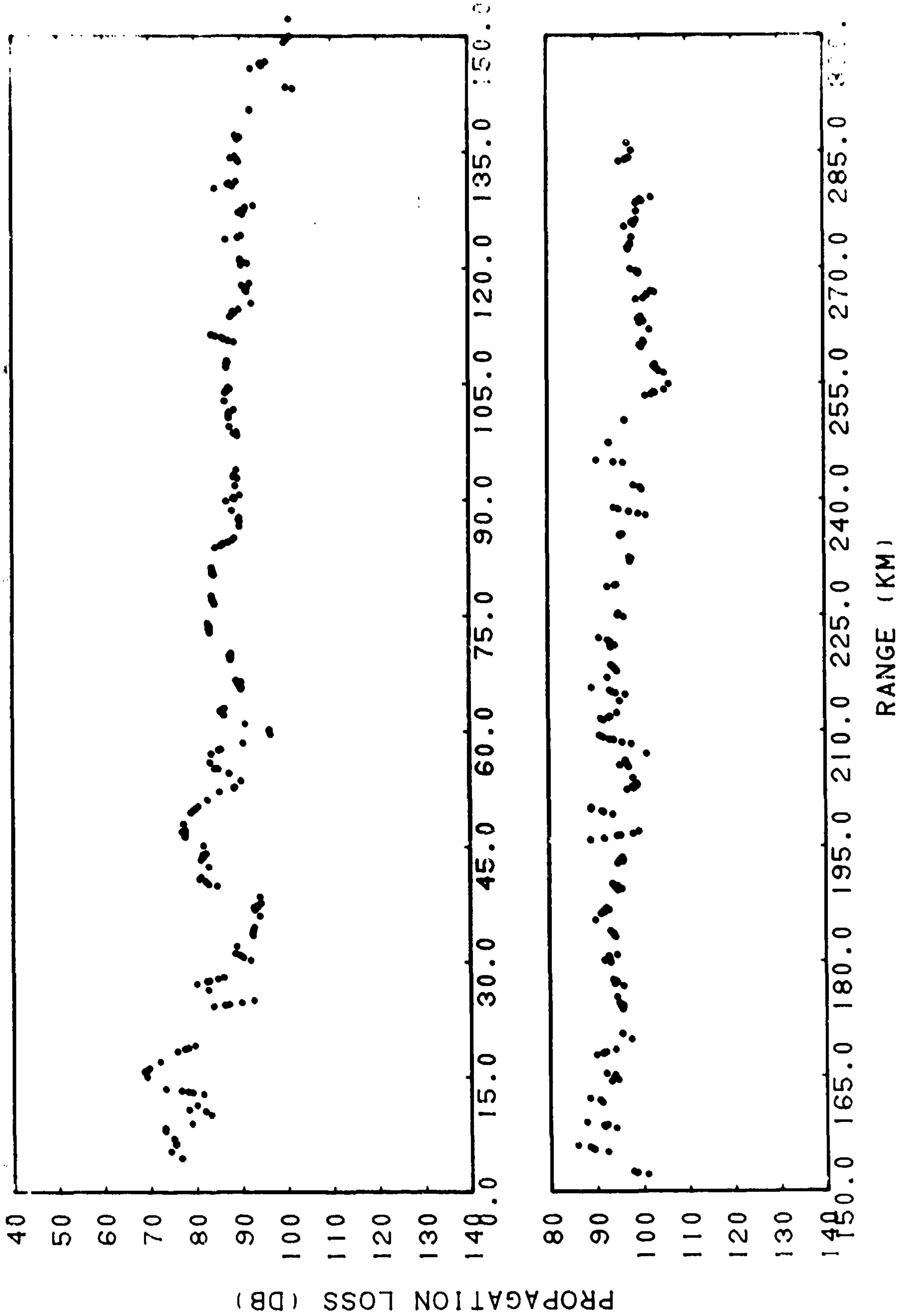
CONFIDENTIAL

(C) Figure IID-23. Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3320 Meters, Frequency = 140 Hertz



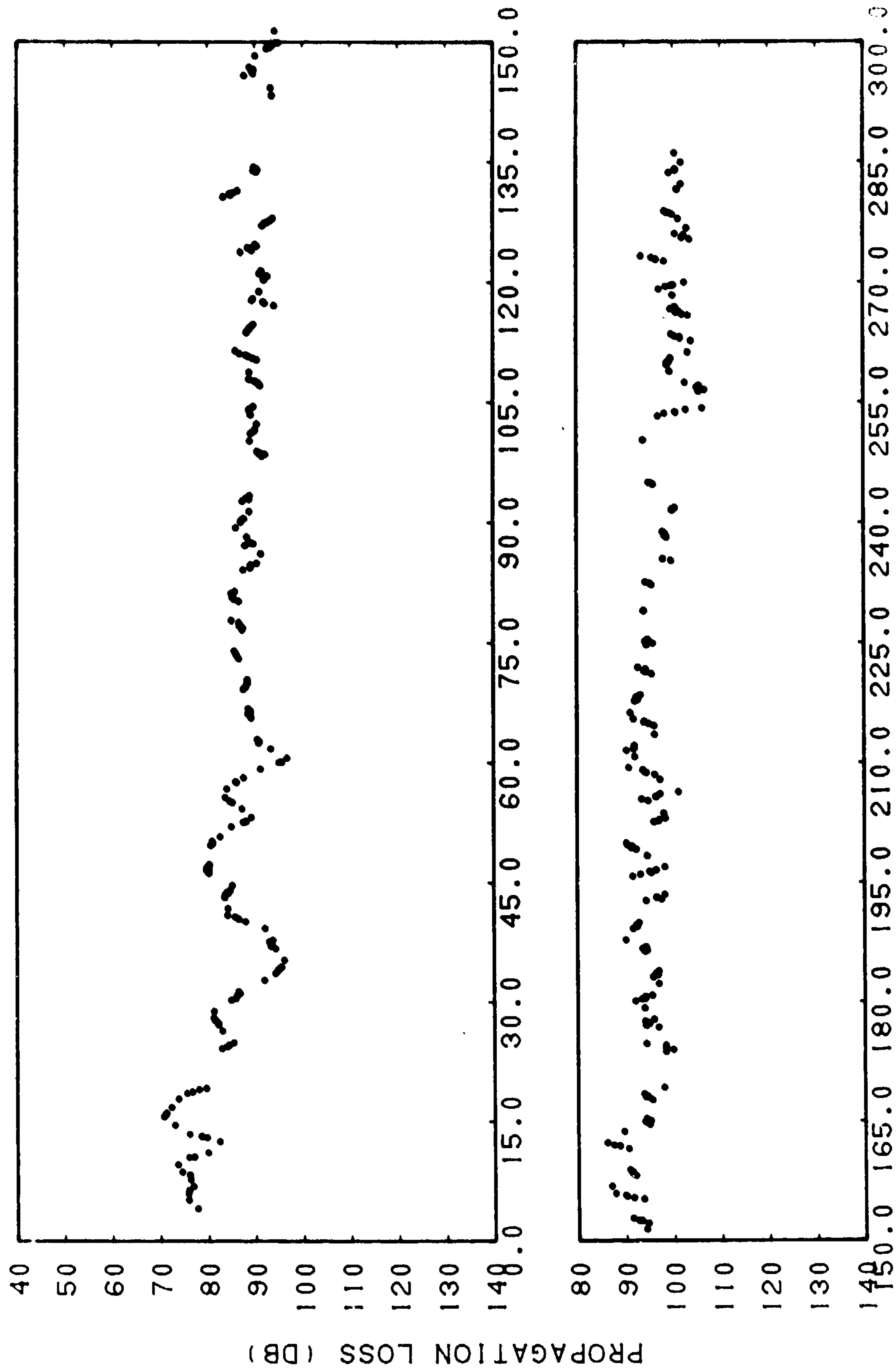
CONFIDENTIAL

(C) Figure IID-22. Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 1685 Meters, Frequency = 140 Hertz



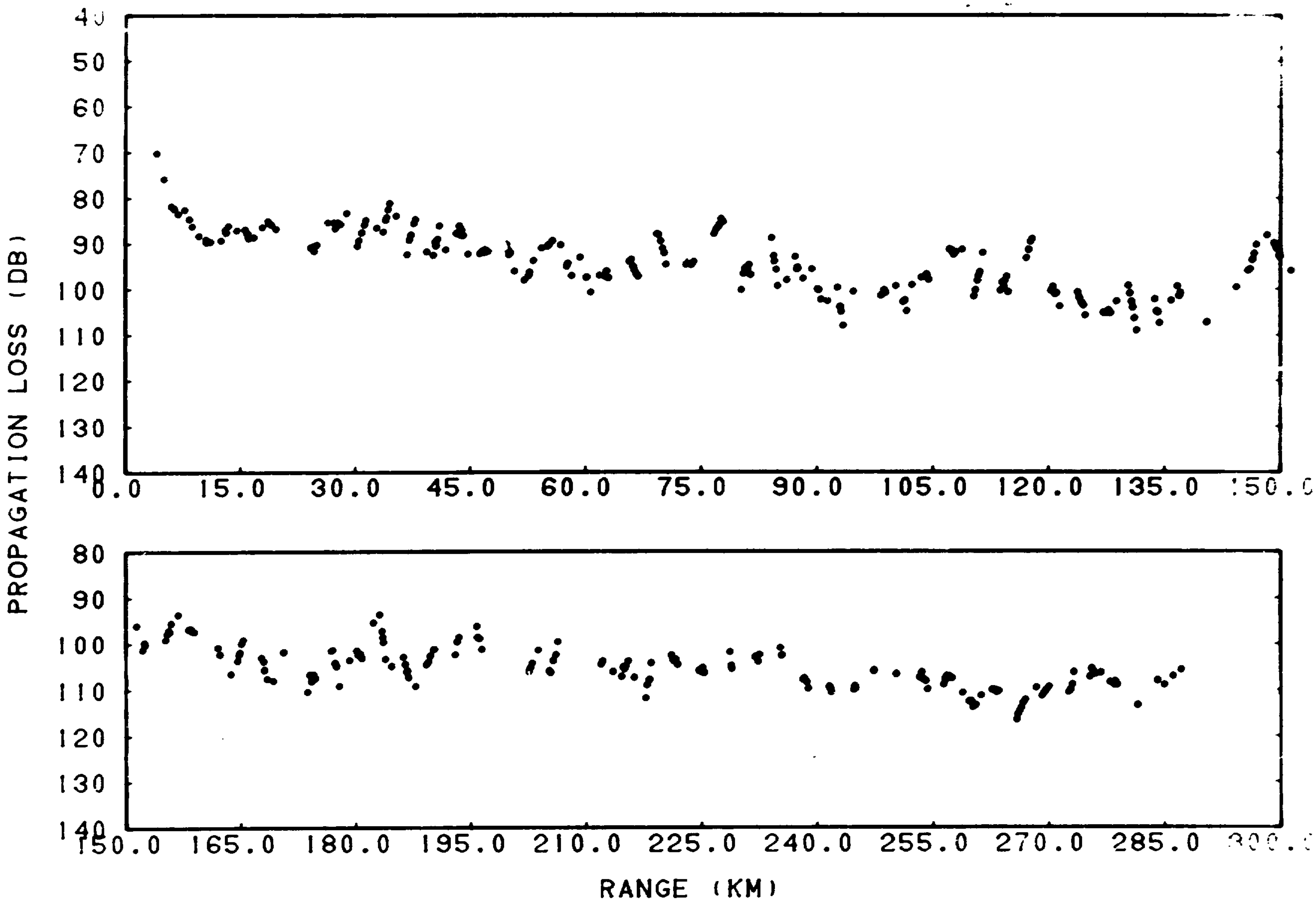
CONFIDENTIAL

(C) Figure IID-23. Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3320 Meters, Frequency = 140 Hertz



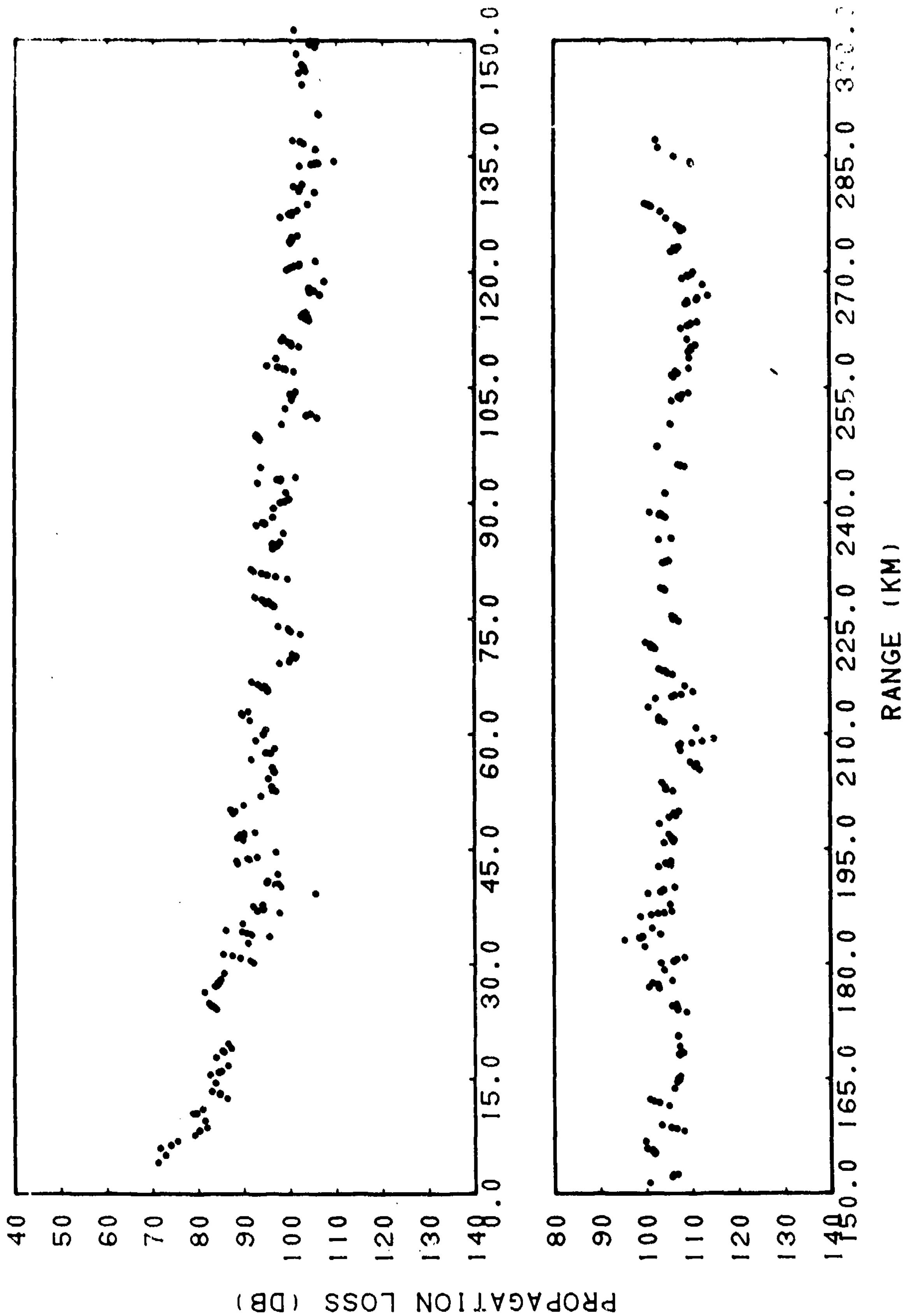
CONFIDENTIAL

(C) Figure IID-24. Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3350 Meters, Frequency = 140 Hertz



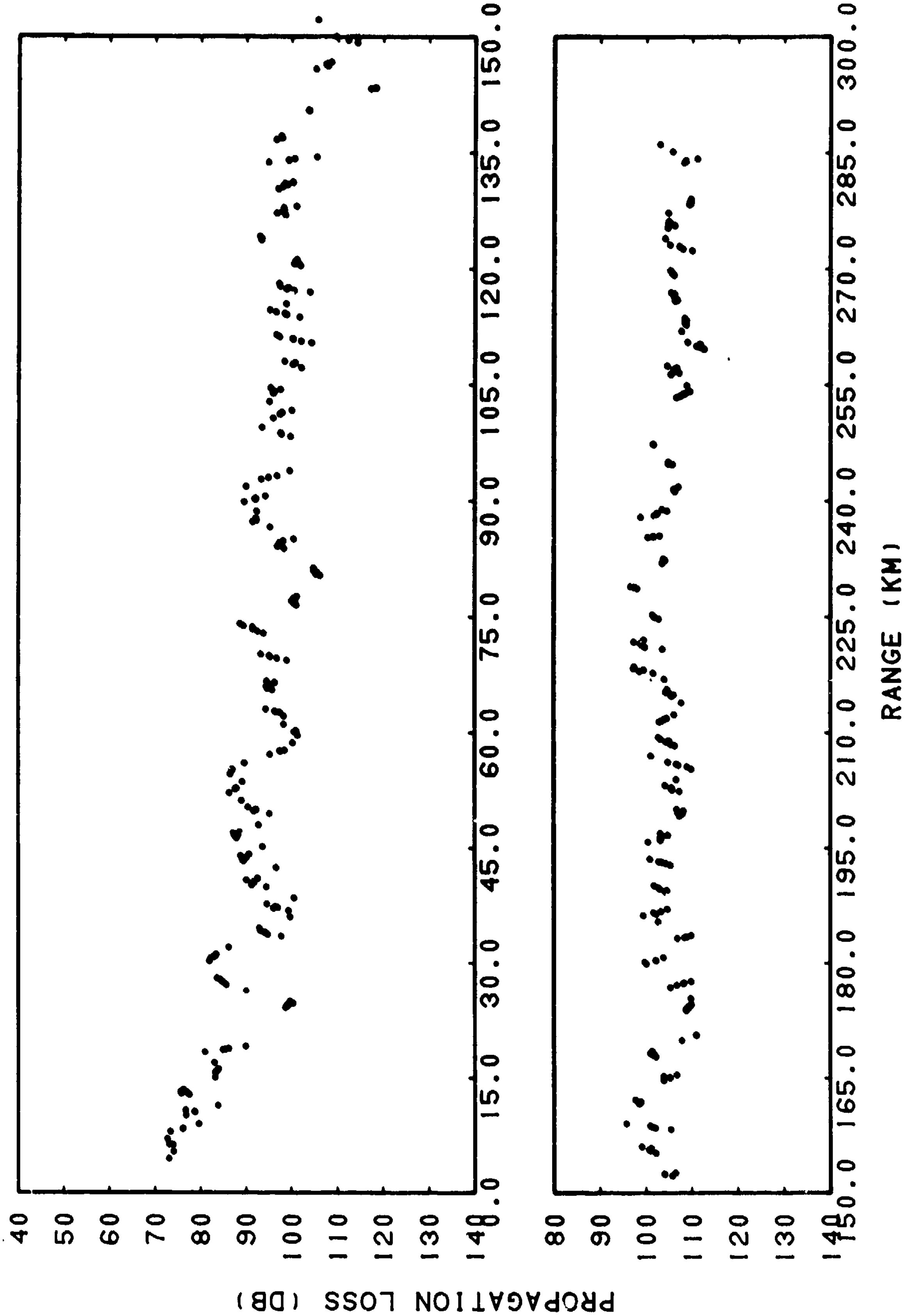
CONFIDENTIAL

(C) Figure IID-25. Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 496 Meters, Frequency = 290 Hertz



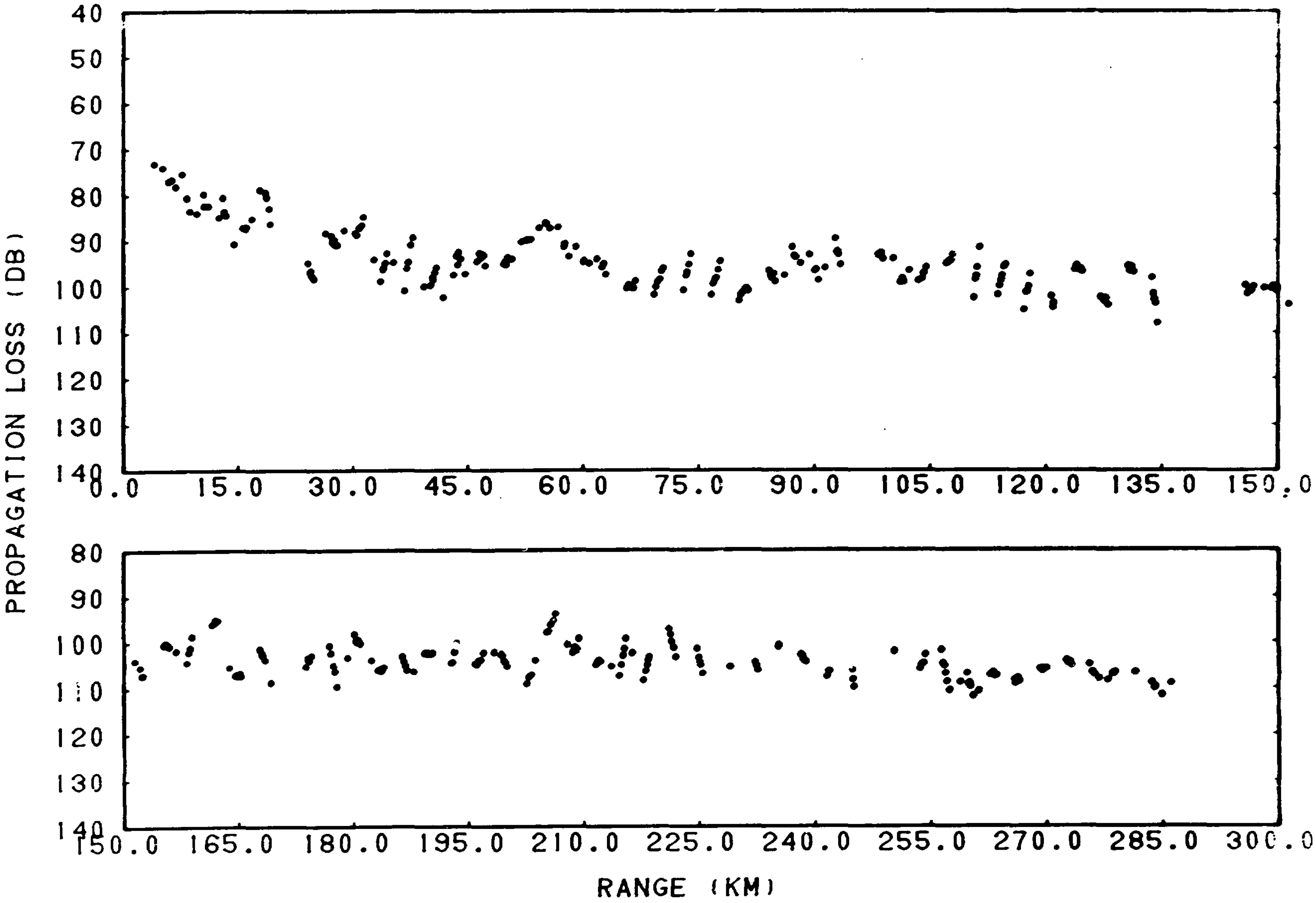
CONFIDENTIAL

(C) Figure IIID-26. Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 1685 Meters, Frequency = 290 Hertz



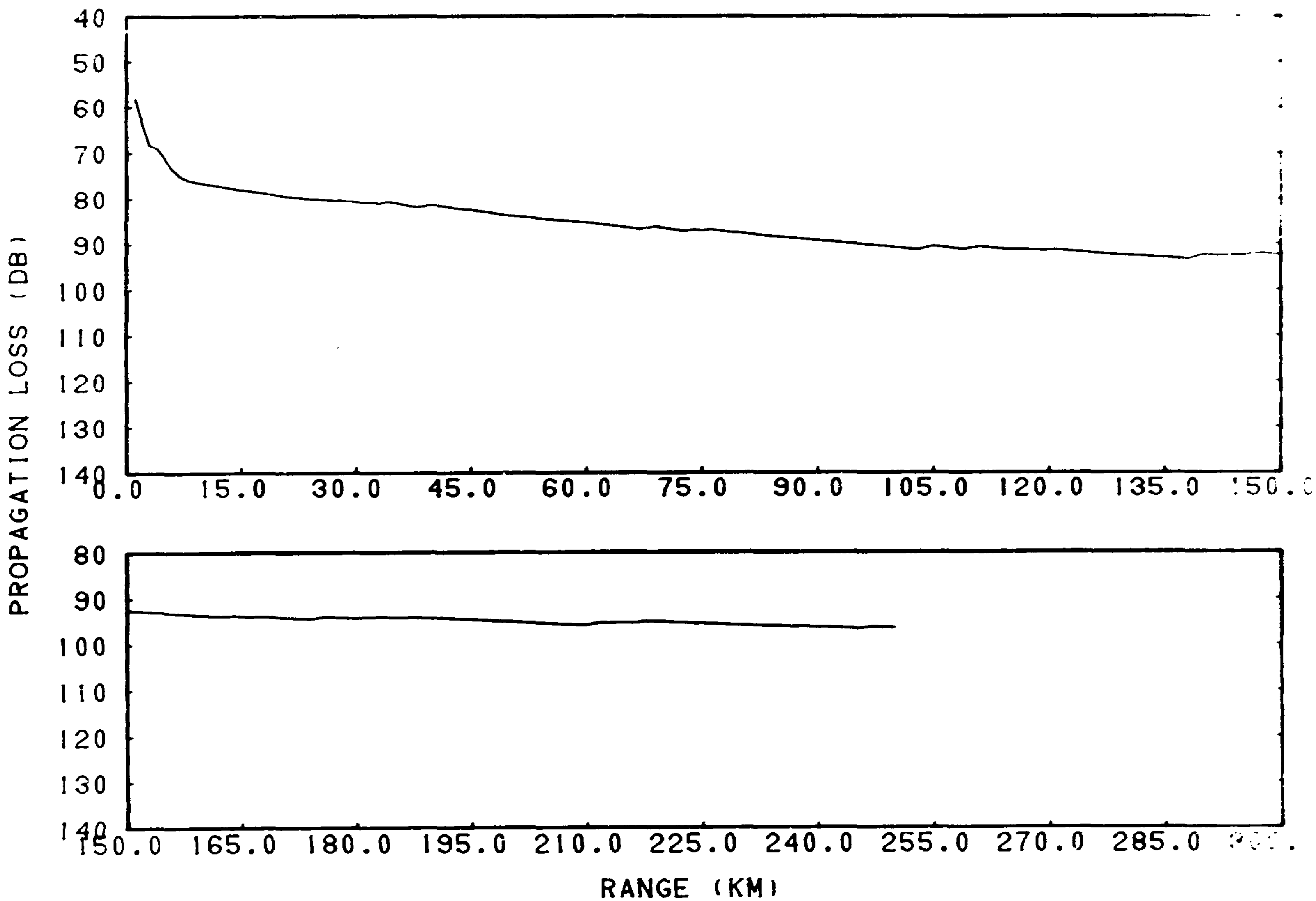
CONFIDENTIAL

(C) Figure IID-27. Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3320 Meters, Frequency = 290 Hertz



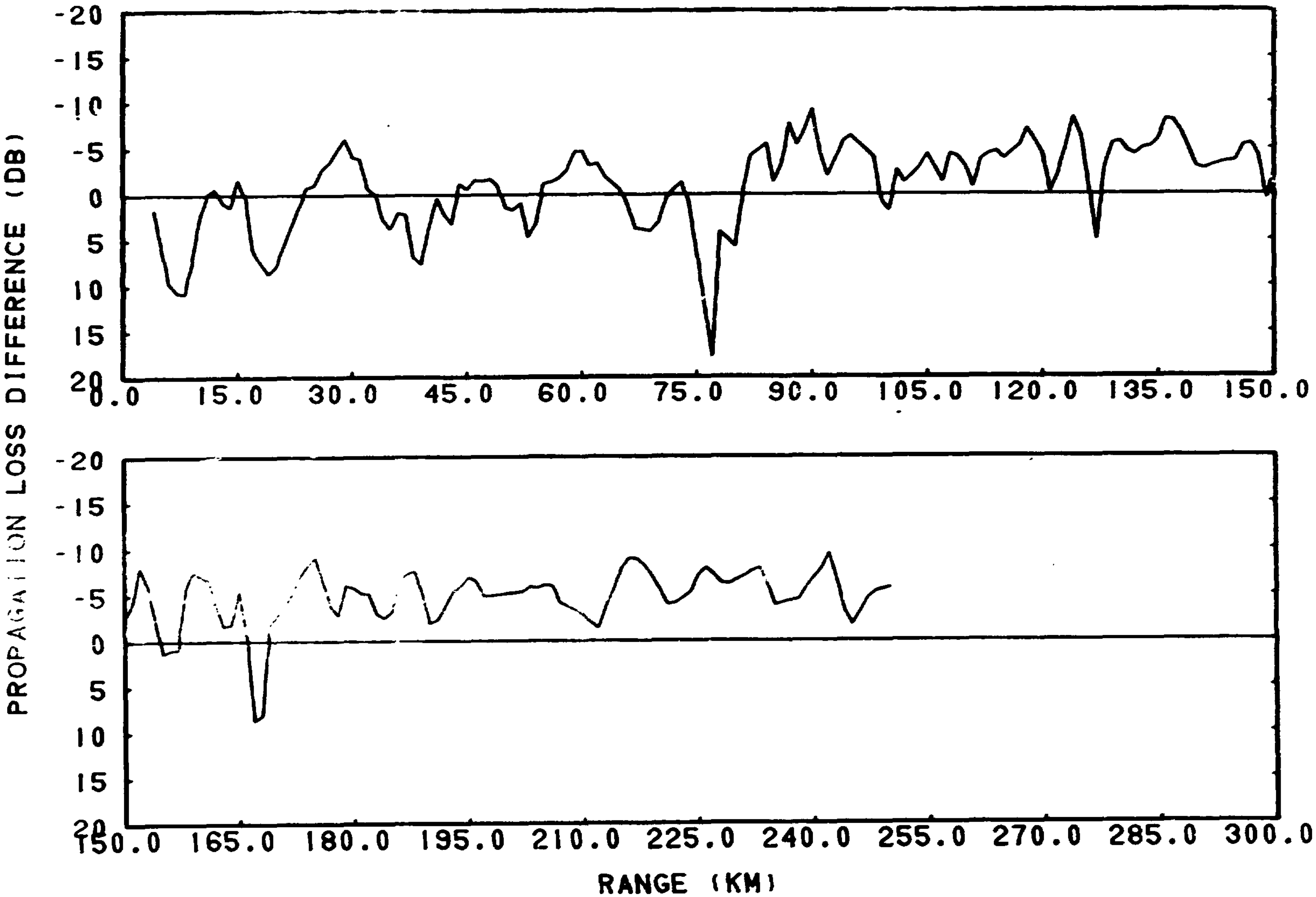
CONFIDENTIAL

(C) Figure IID-28. Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3350 Meters, Frequency = 290 Hertz



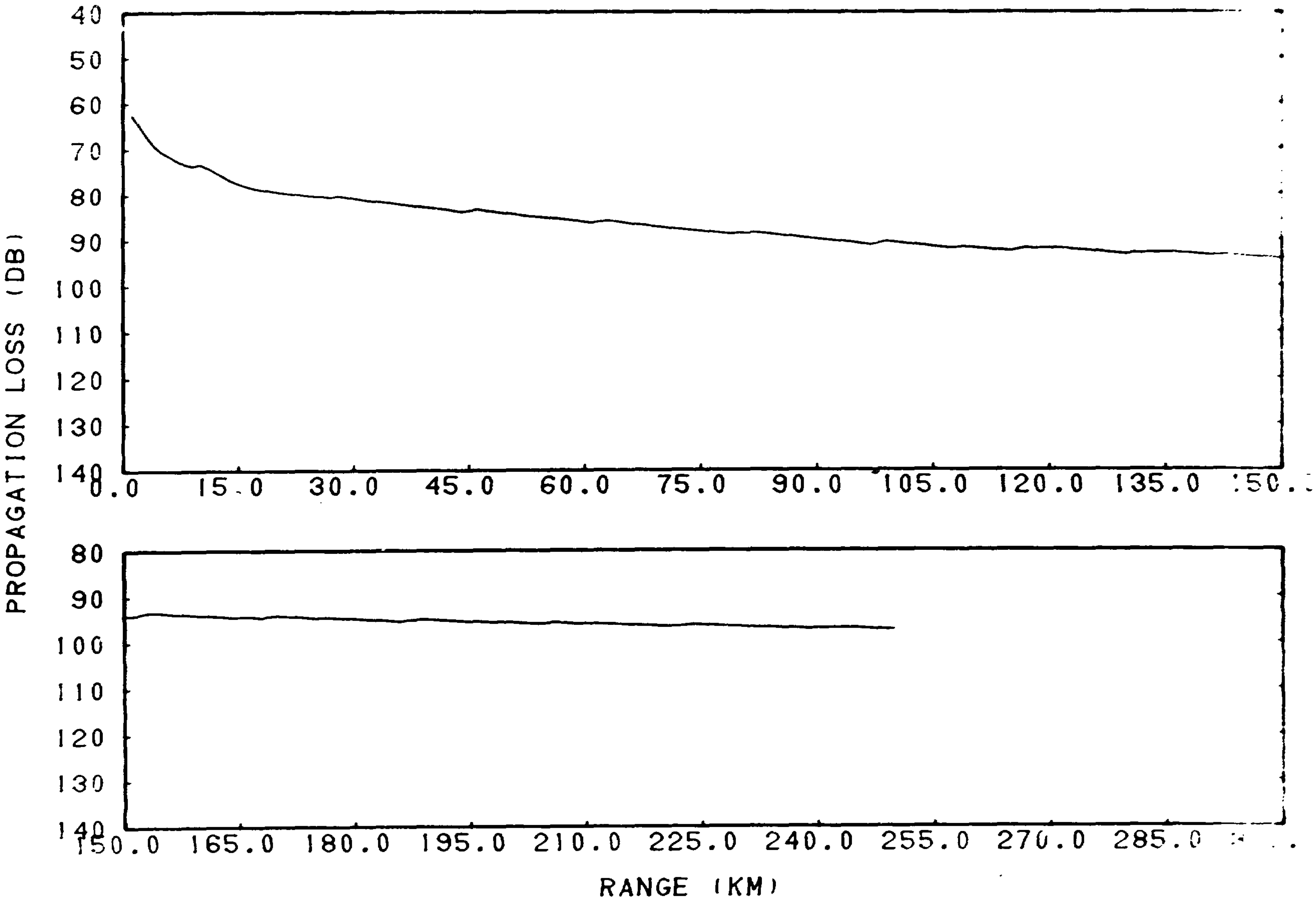
CONFIDENTIAL

(C) Figure IID-29. FACT Coherent Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 496 Meters, Frequency = 25 Hertz



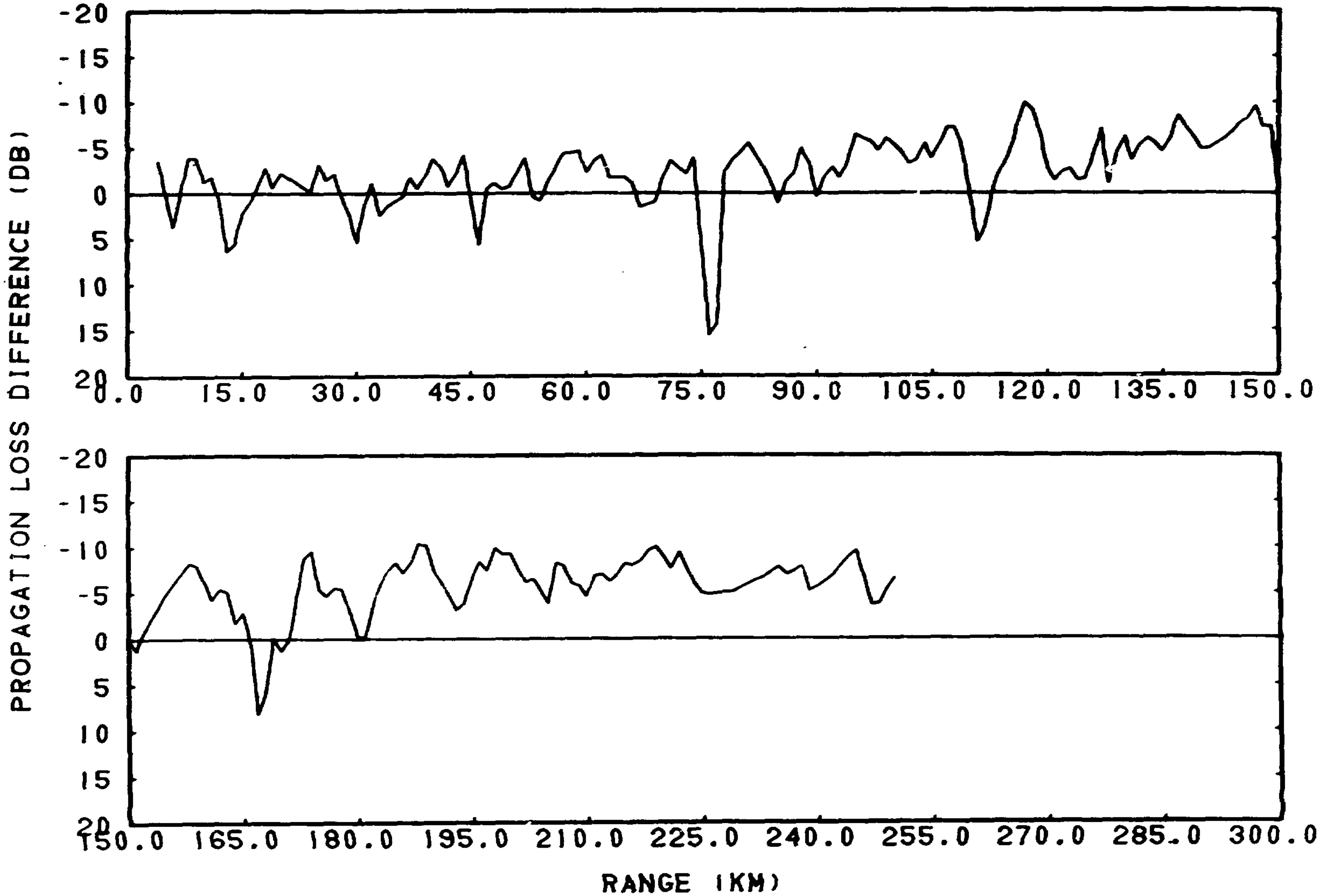
CONFIDENTIAL

(C) Figure IID-30. FACT Coherent Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 496 Meters, Frequency = 25 Hertz, Subtracted from Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 496 Meters, Frequency = 25 Hertz



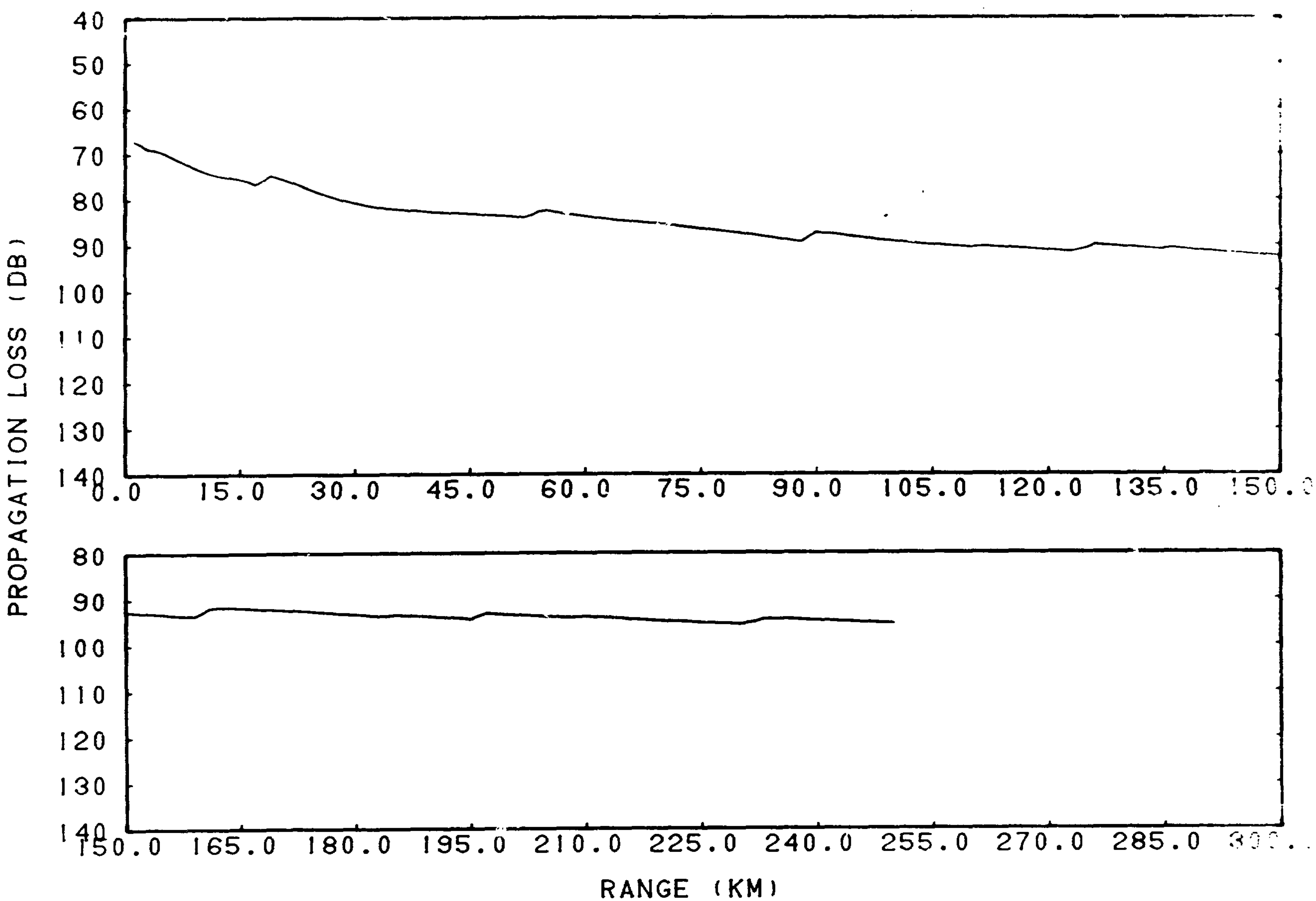
CONFIDENTIAL

(C) Figure IID-31. FACT Coherent Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 1685 Meters, Frequency = 25 Hertz



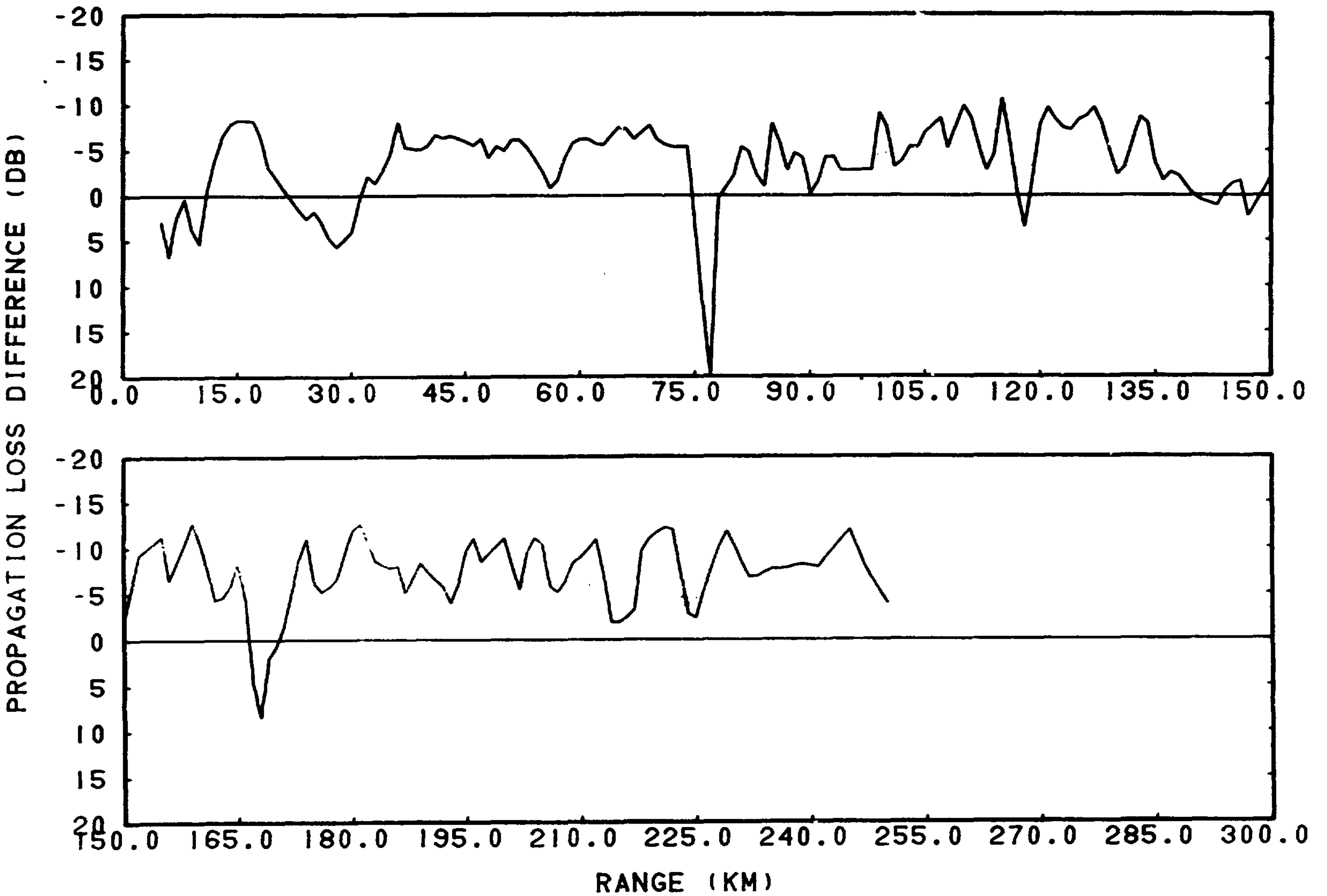
CONFIDENTIAL

(C) Figure IID-32. FACT Coherent Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 1685 Meters, Frequency = 25 Hertz, Subtracted from Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 1685 Meters, Frequency = 25 Hertz



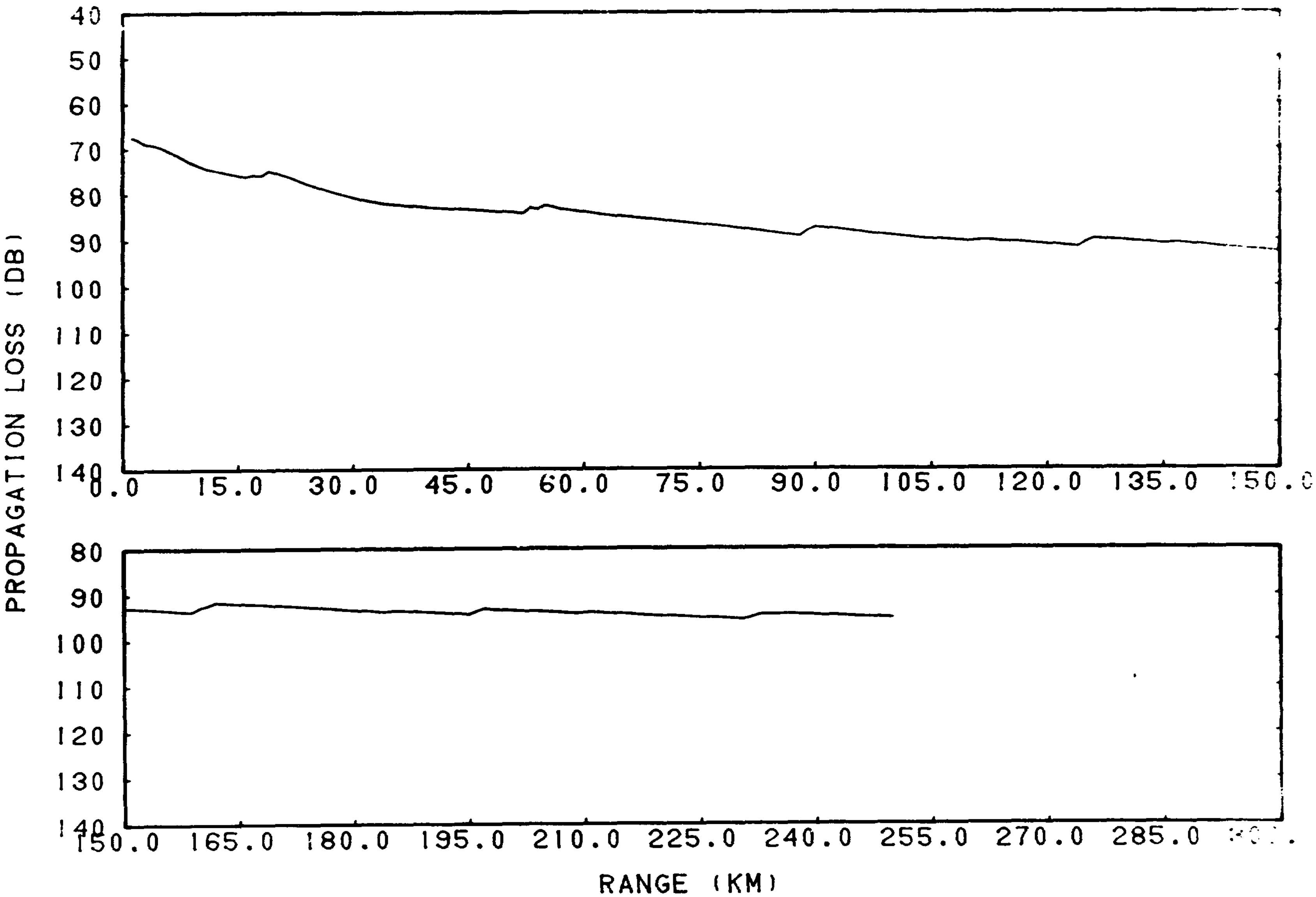
CONFIDENTIAL

(C) Figure IID-33. FACT Coherent Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 3320 Meters, Frequency = 25 Hertz



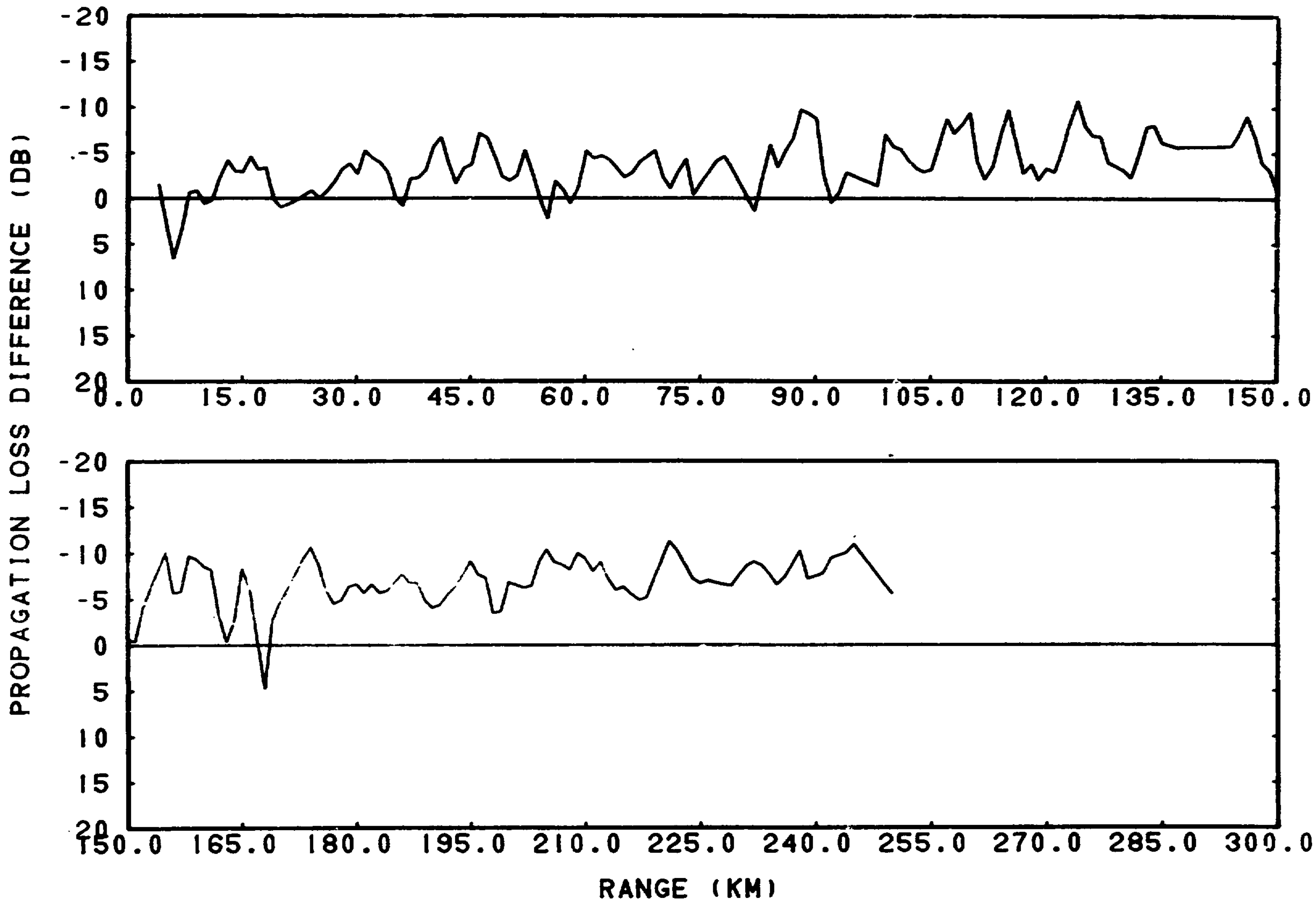
CONFIDENTIAL

(C) Figure IID-34. FACT Coherent Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 3320 Meters, Frequency = 25 Hertz, Subtracted from Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 3320 Meters, Frequency = 25 Hertz



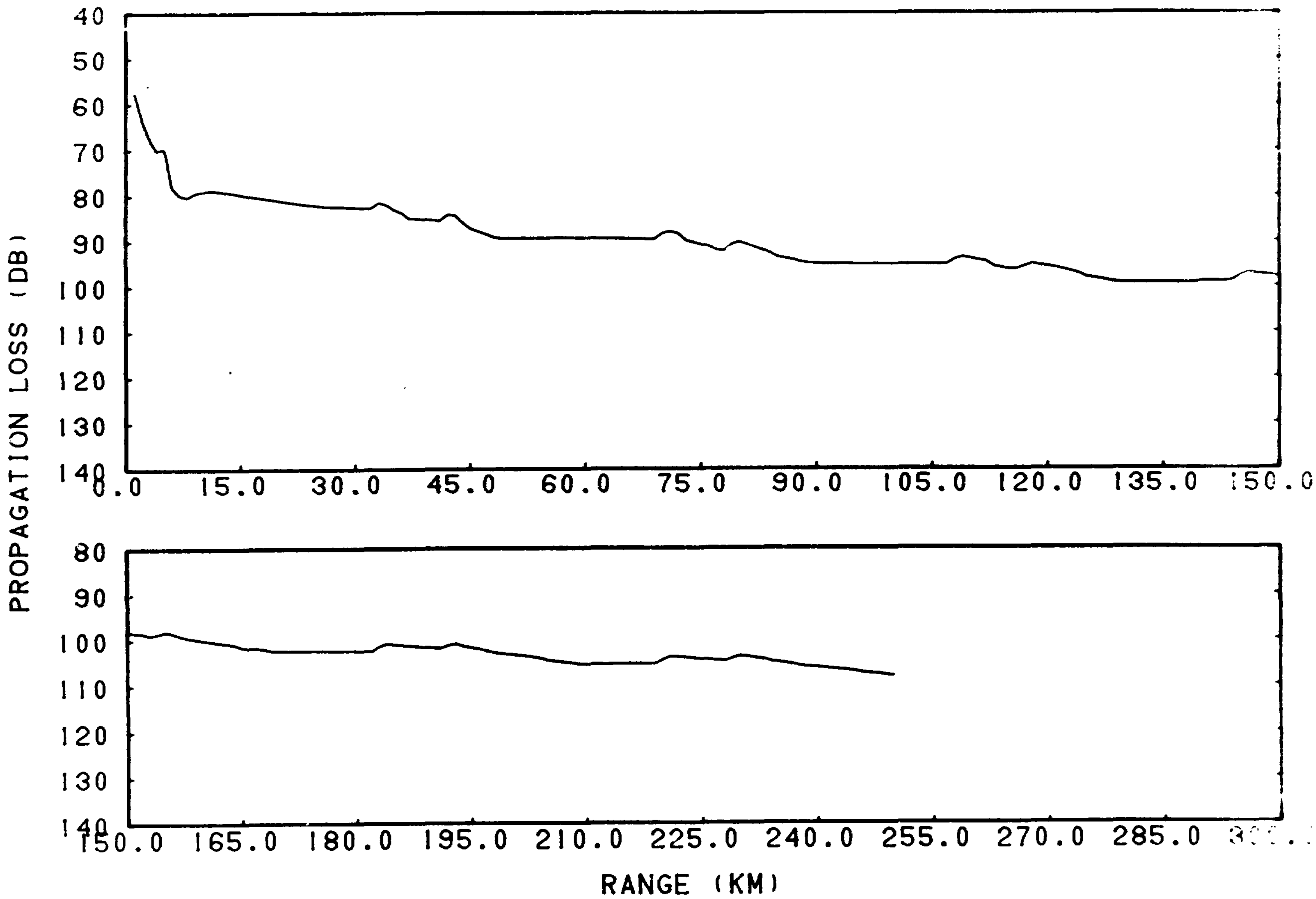
CONFIDENTIAL

(C) Figure IID-35. FACT Coherent Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 3350 Meters, Frequency = 25 Hertz



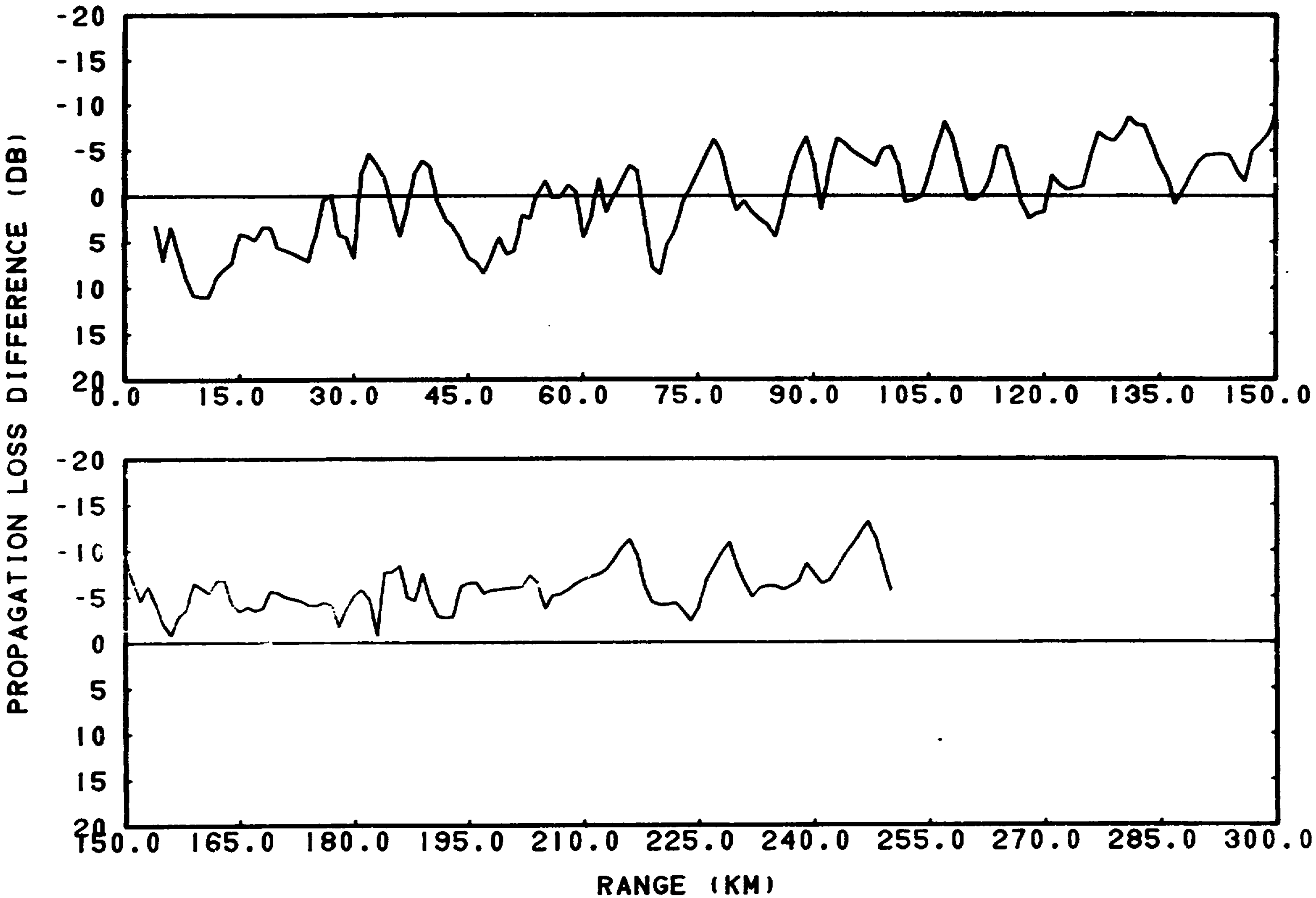
CONFIDENTIAL

(C) Figure IID-36. FACT Coherent Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 3350 Meters, Frequency = 25 Hertz, Subtracted from Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 3350 Meters, Frequency = 25 Hertz



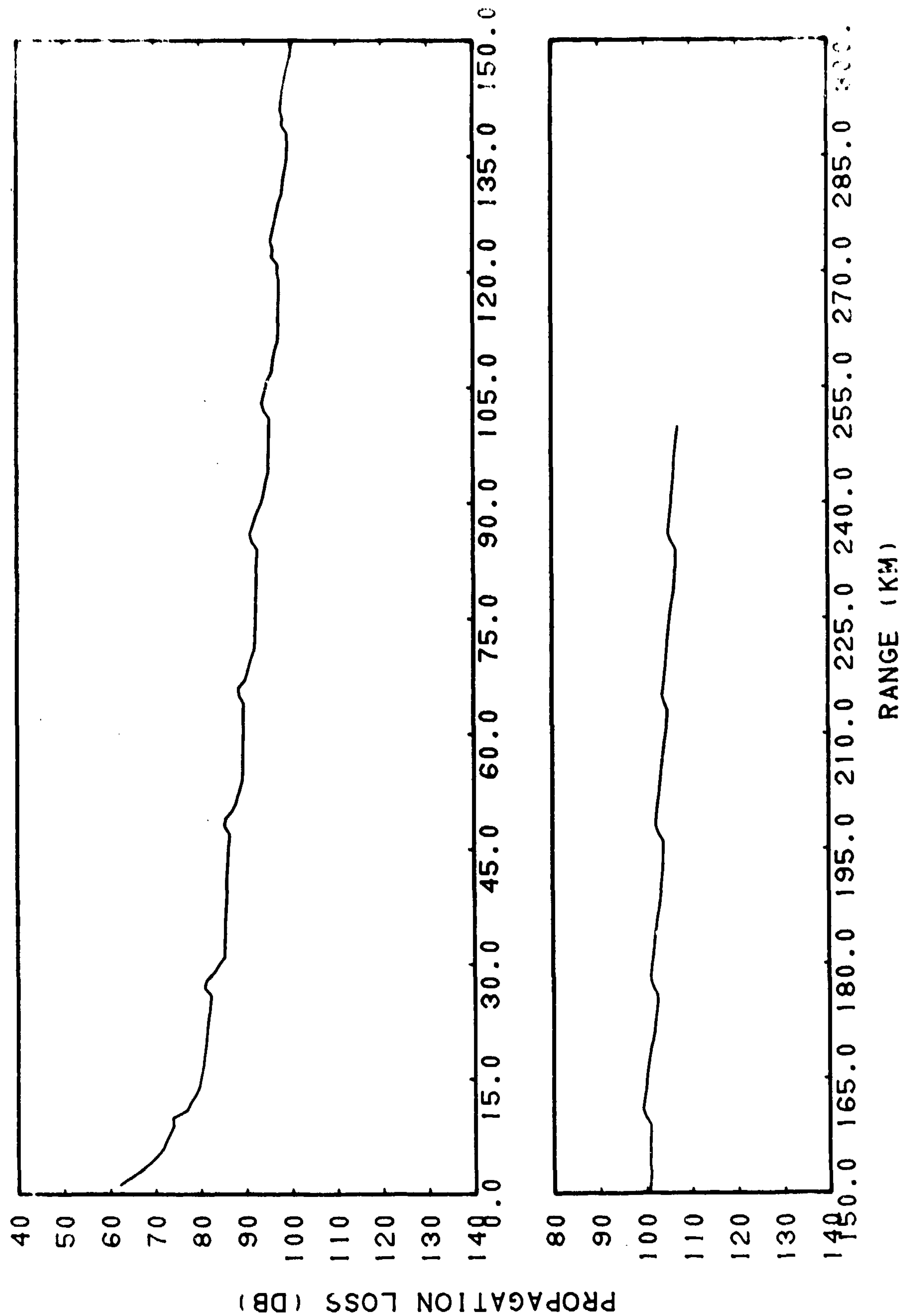
CONFIDENTIAL

(C) Figure IID-37. FACT Coherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 496 Meters, Frequency = 140 Hertz



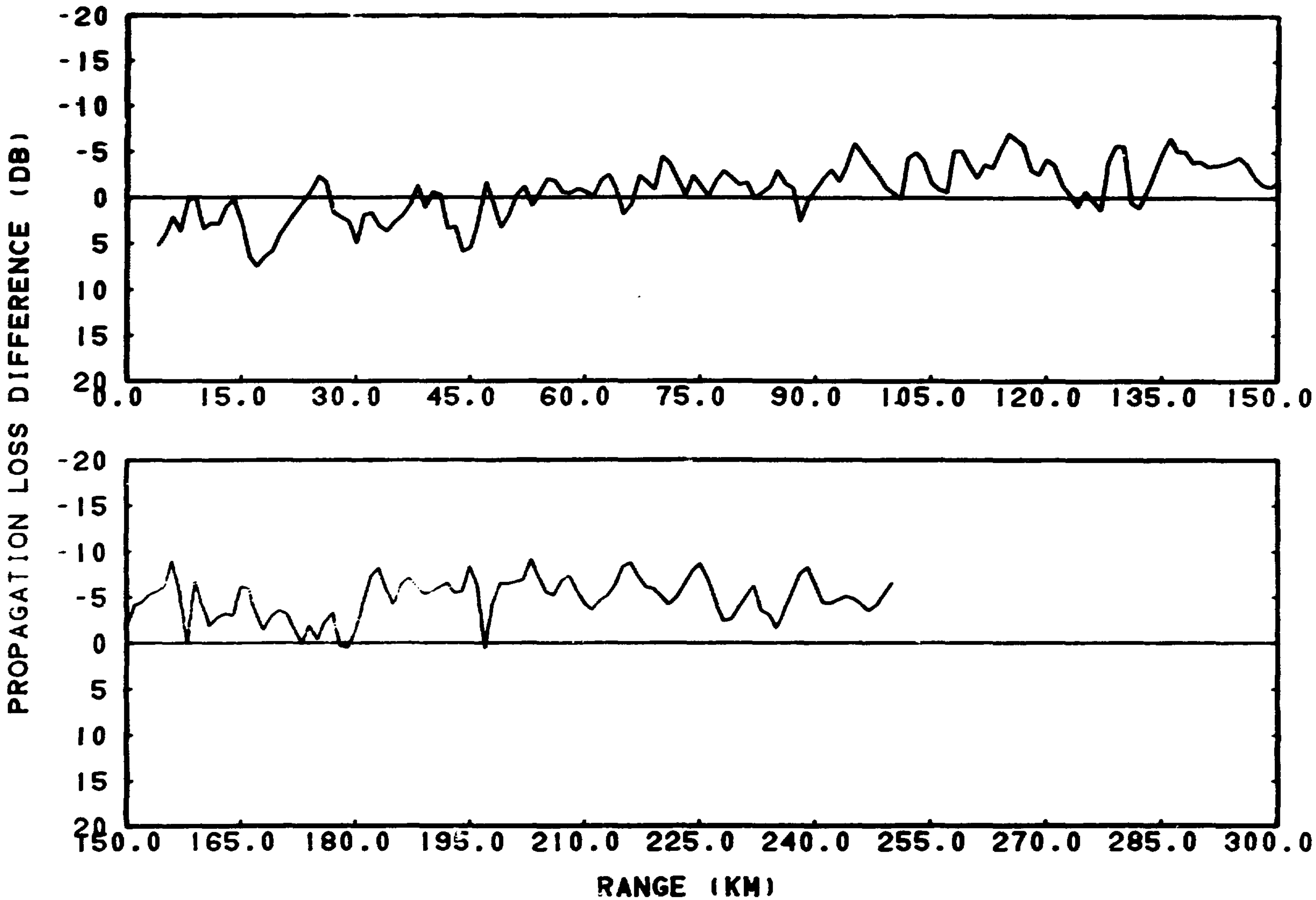
CONFIDENTIAL

(C) Figure IID-38. FACT Coherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 496 Meters, Frequency = 140 Hertz, Subtracted from Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 496 Meters, Frequency = 140 Hertz



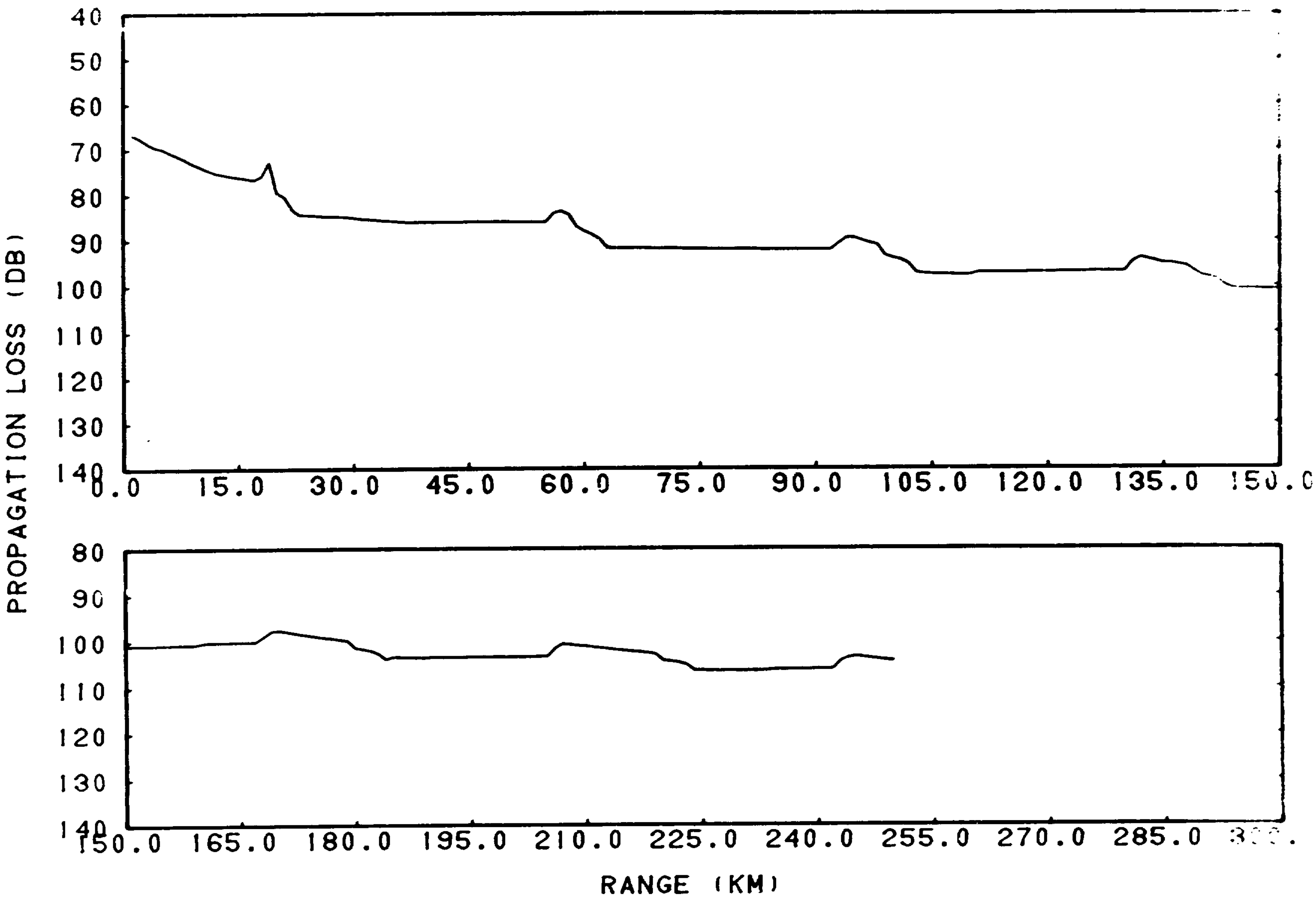
CONFIDENTIAL

(C) Figure IID-39. FACT Coherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 1685 Meters, Frequency = 140 Hertz



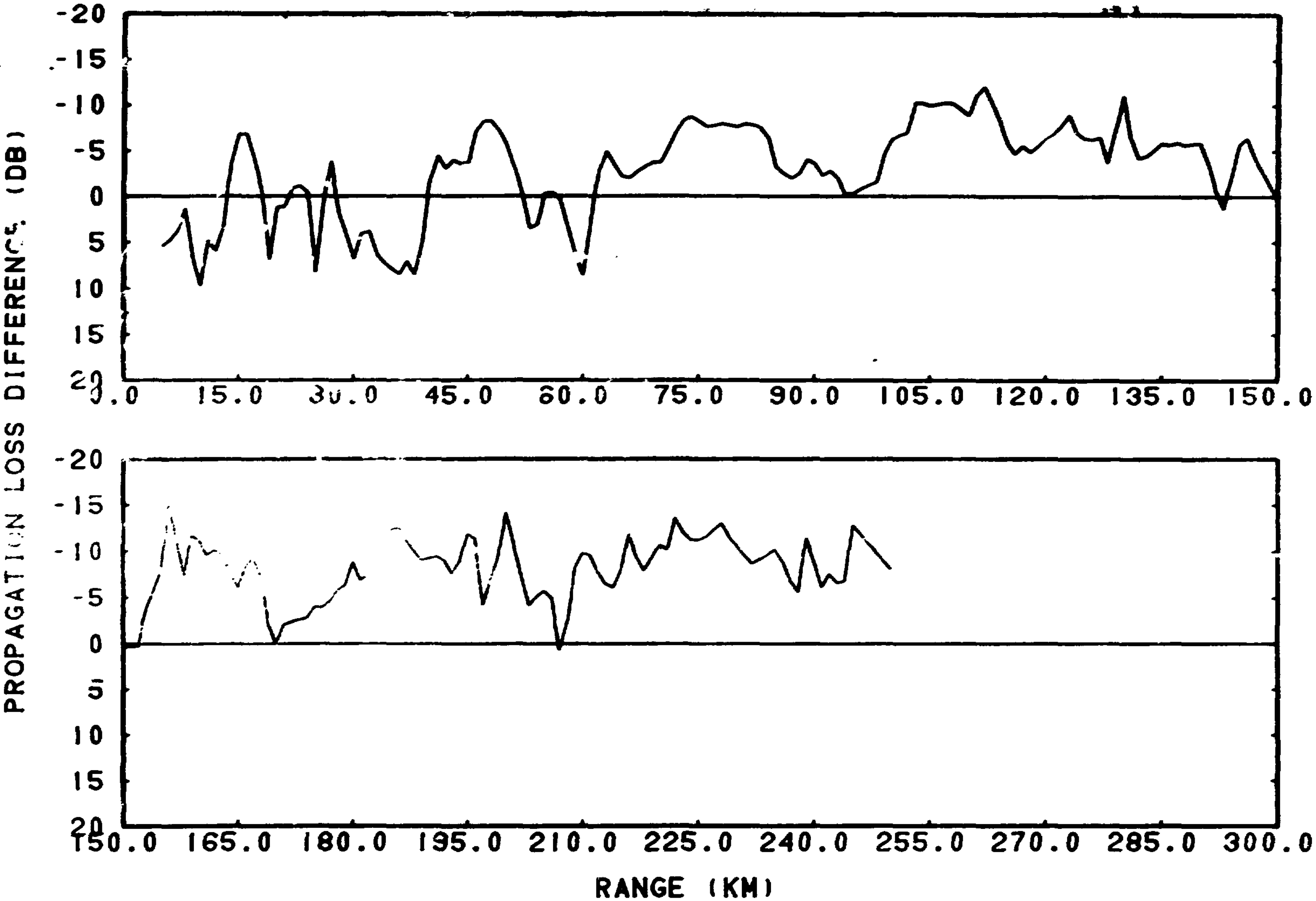
CONFIDENTIAL

(C) Figure IID-40. FACT Coherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 1685 Meters, Frequency = 140 Hertz, Subtracted from Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 1685 Meters, Frequency = 140 Hertz



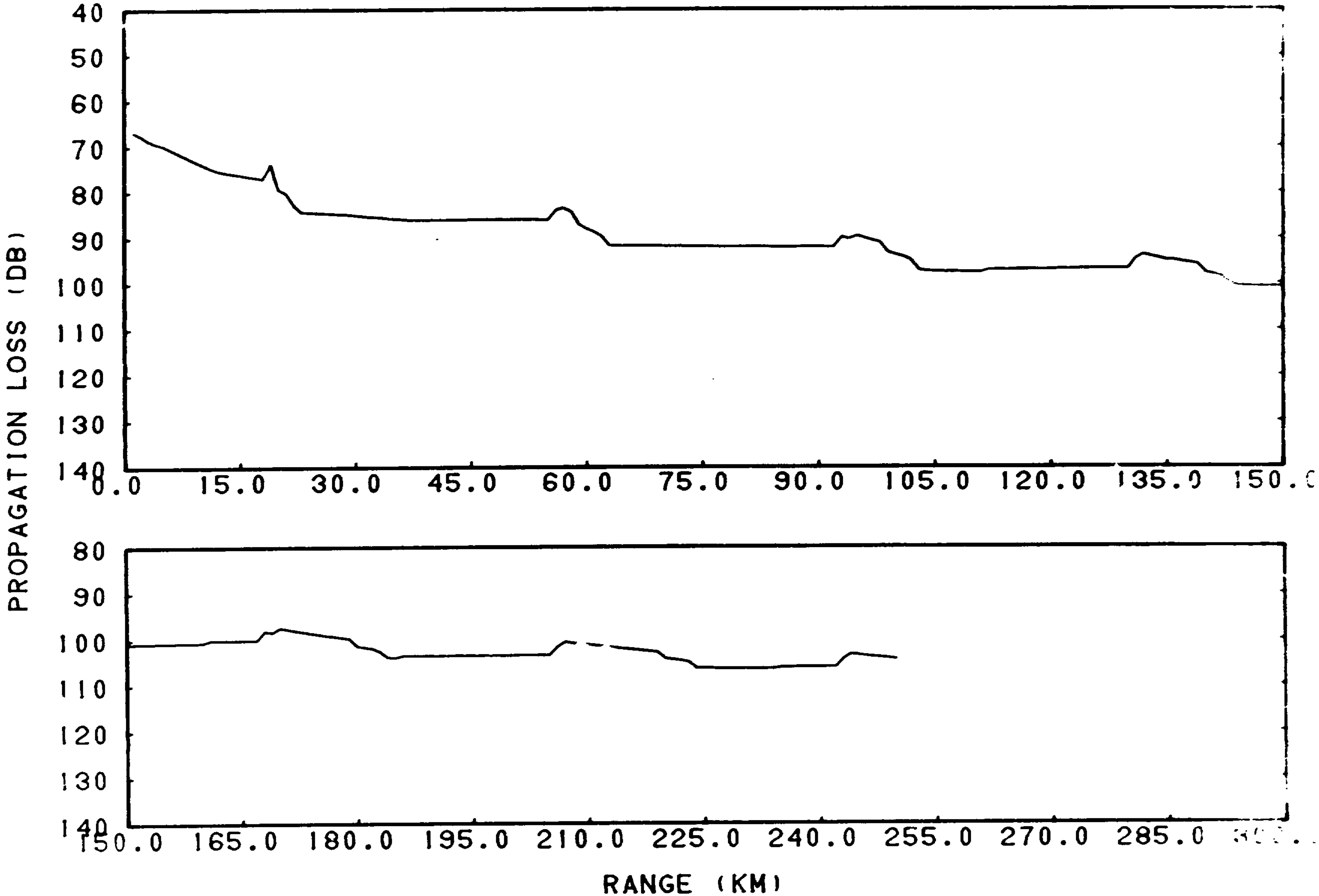
CONFIDENTIAL

(C) Figure IID-41. FACT Coherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3320 Meters, Frequency = 140 Hertz



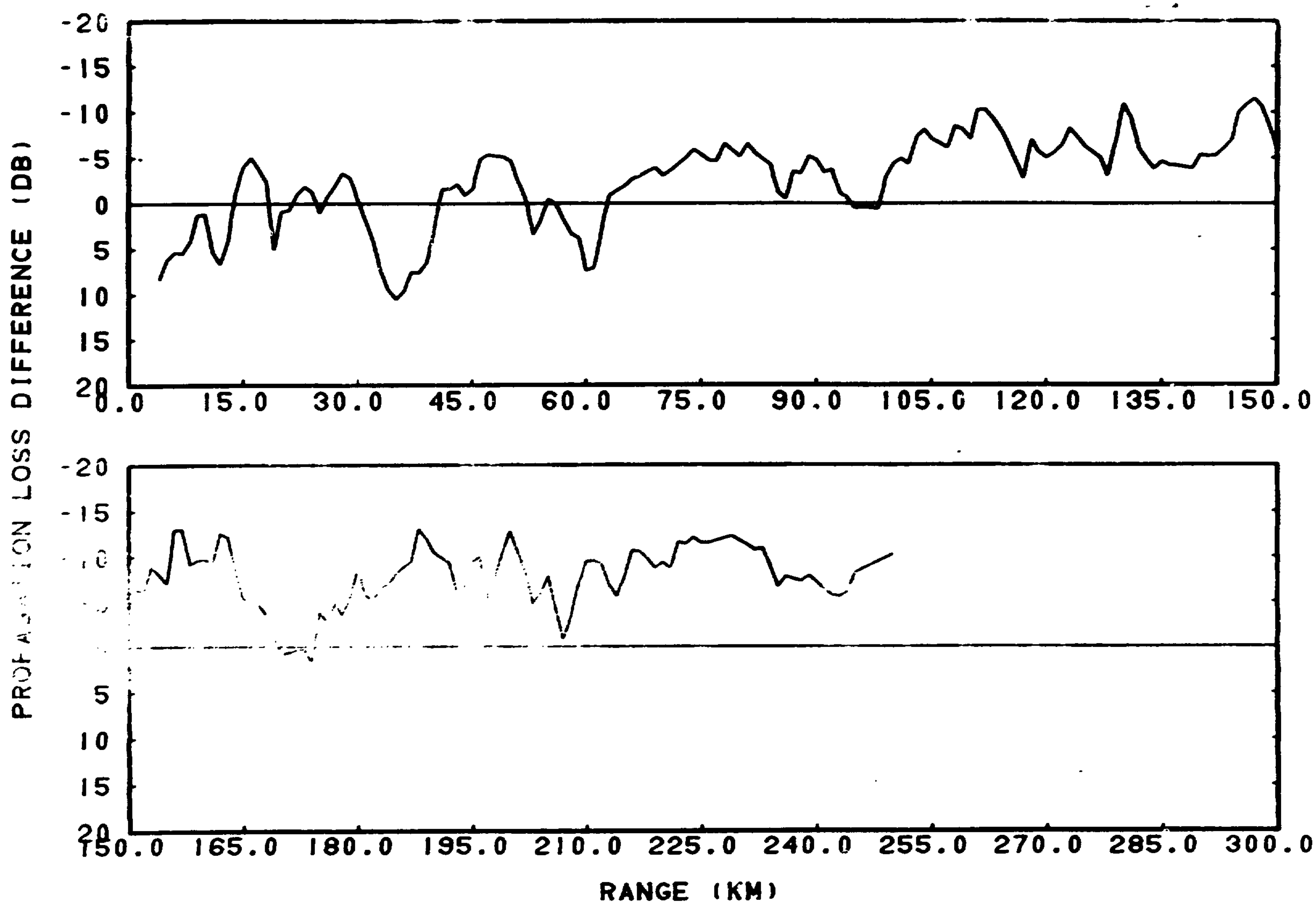
CONFIDENTIAL

(C) Figure IID-42. FACT Coherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3320 Meters, Frequency = 140 Hertz, Subtracted from Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3320 Meters, Frequency = 140 Hertz



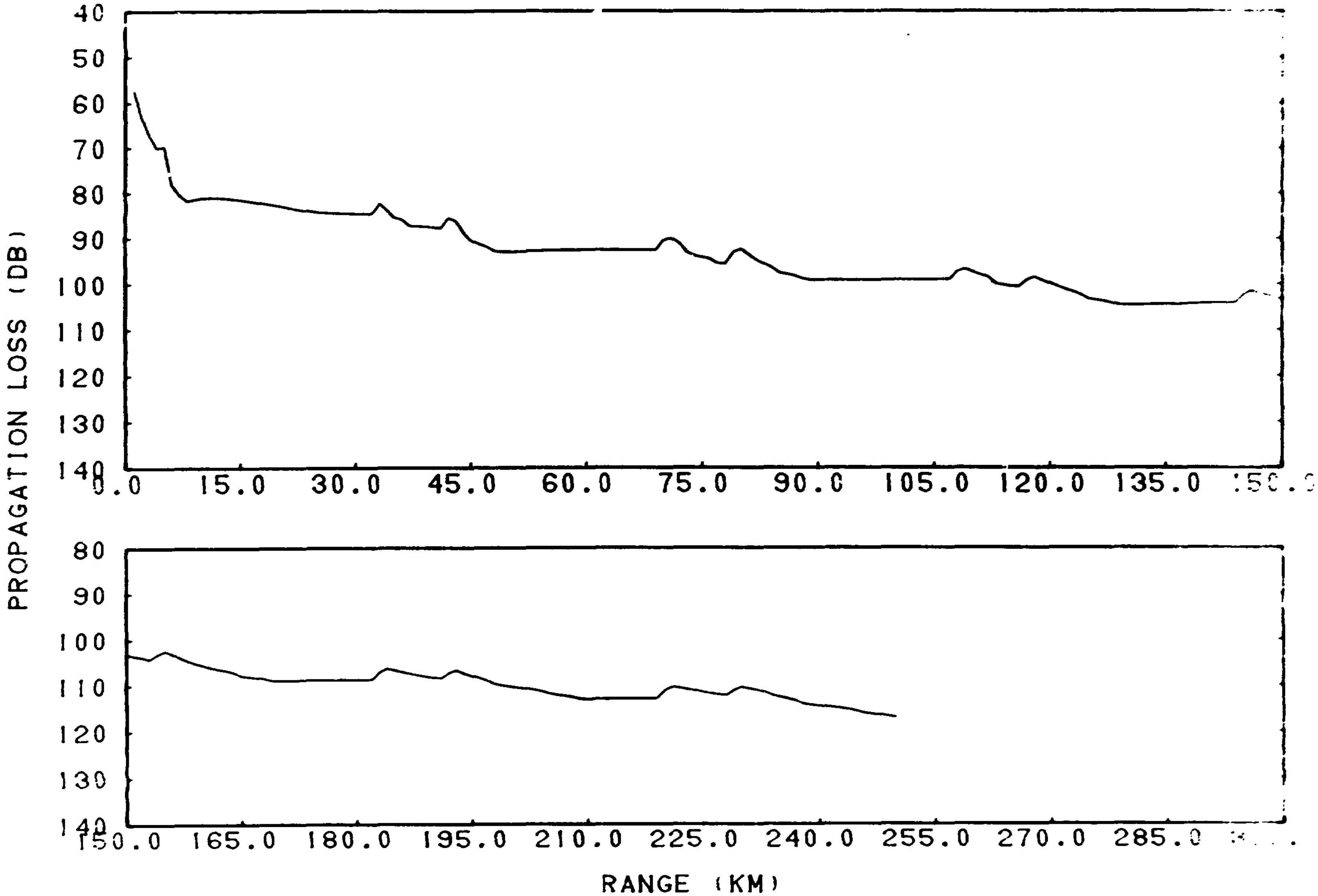
CONFIDENTIAL

(C) Figure IID-43. FACT Coherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3350 Meters, Frequency = 140 Hertz



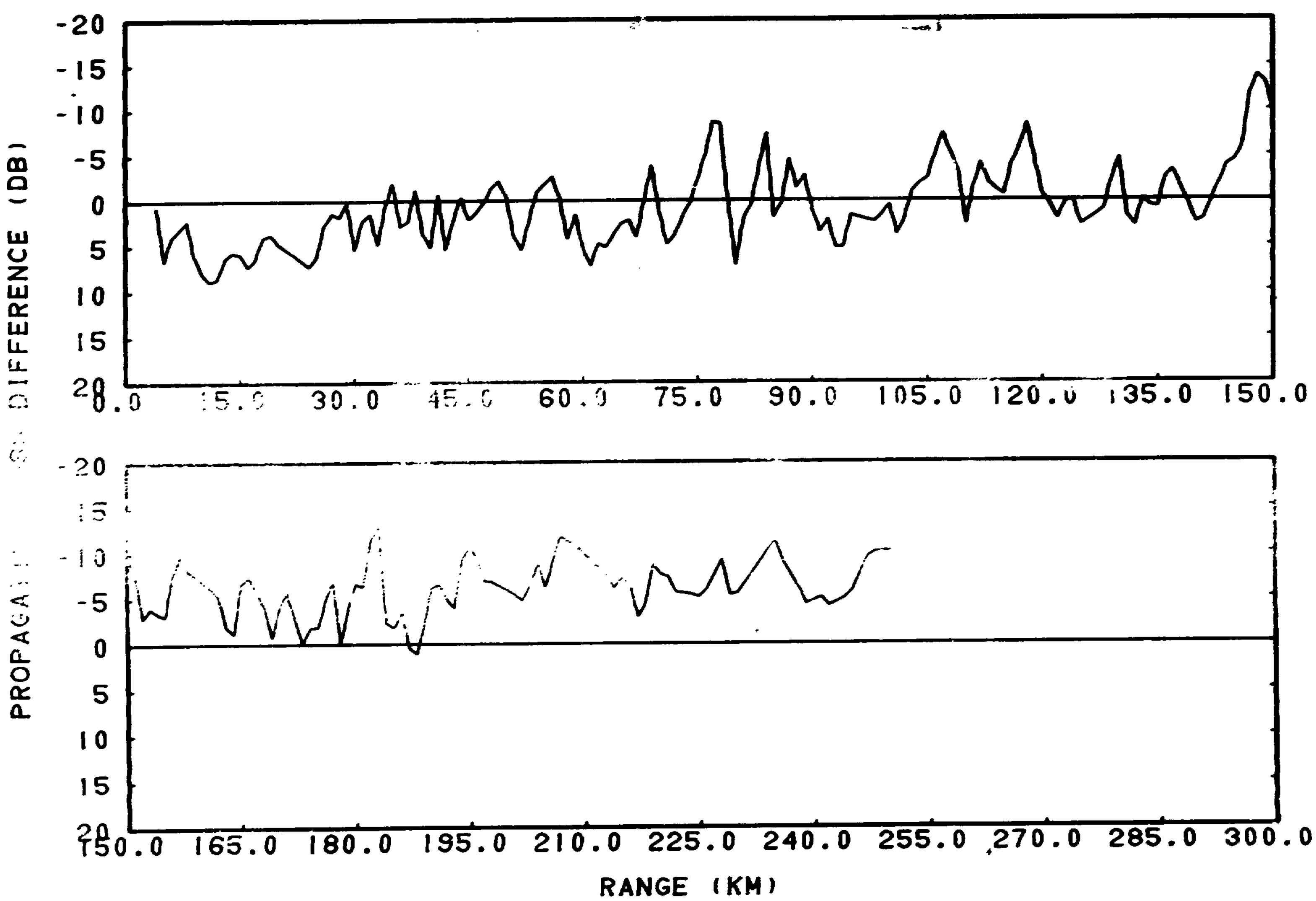
CONFIDENTIAL

(C) Figure IID-44. FACT Coherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3350 Meters, Frequency = 140 Hertz, Subtracted from Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters Receiver Depth = 3350 Meters, Frequency = 140 Hertz



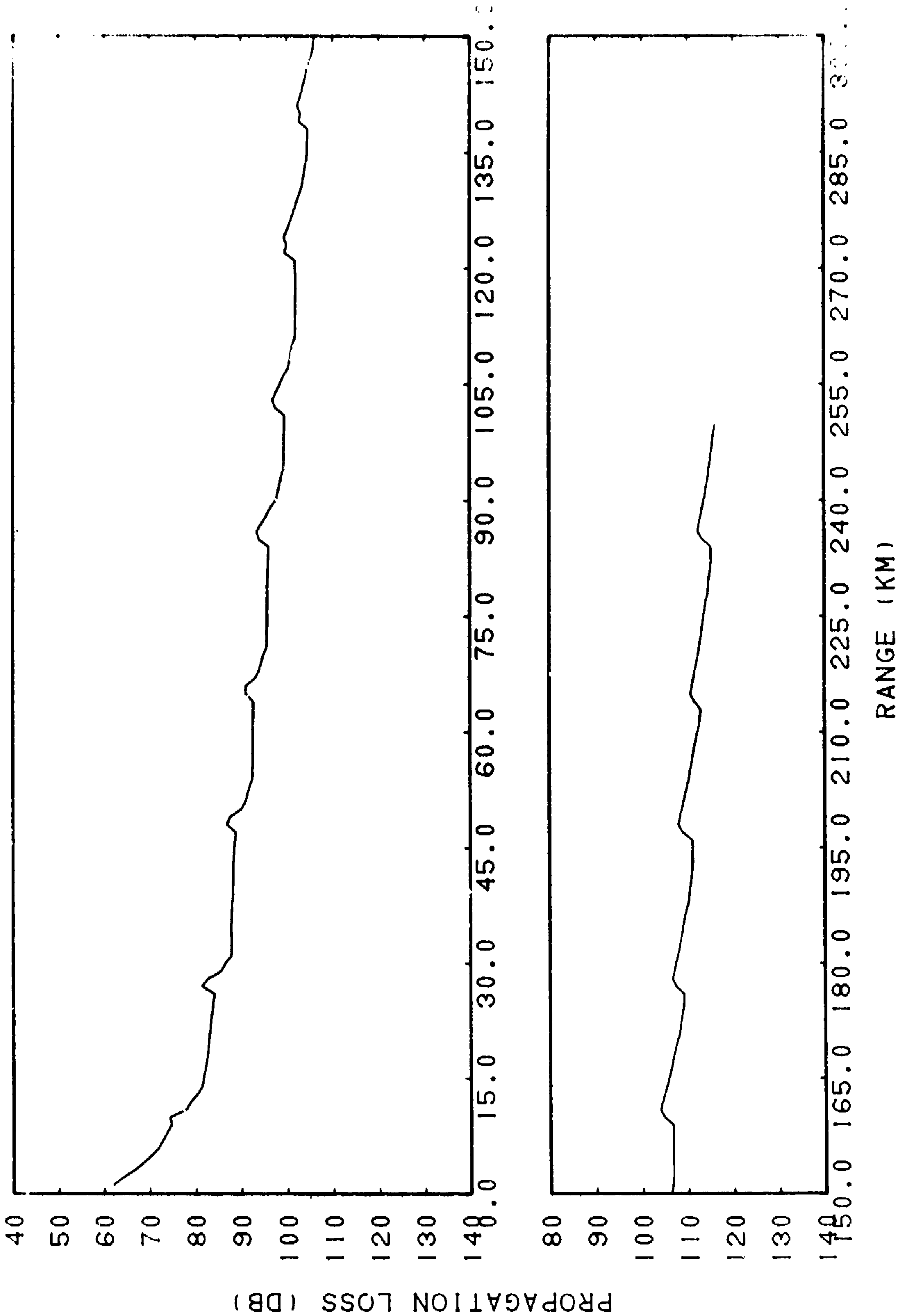
CONFIDENTIAL

(C) Figure IID-45. FACT Coherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 496 Meters, Frequency = 290 Hertz



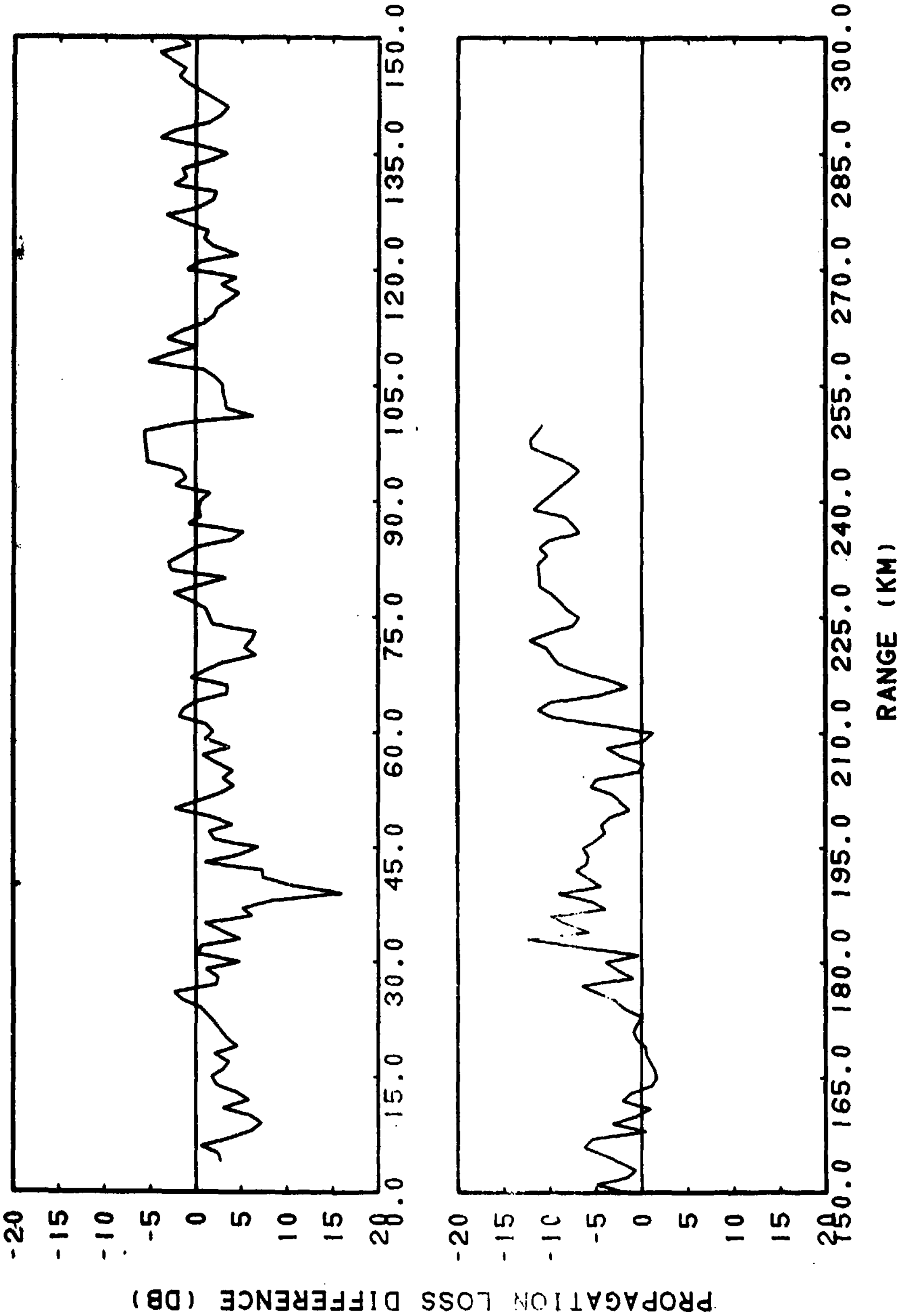
CONFIDENTIAL

(C) Figure IID-46. FACT Coherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 496 Meters, Frequency = 290 Hertz, Subtracted from Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 496 Meters, Frequency = 290 Hertz



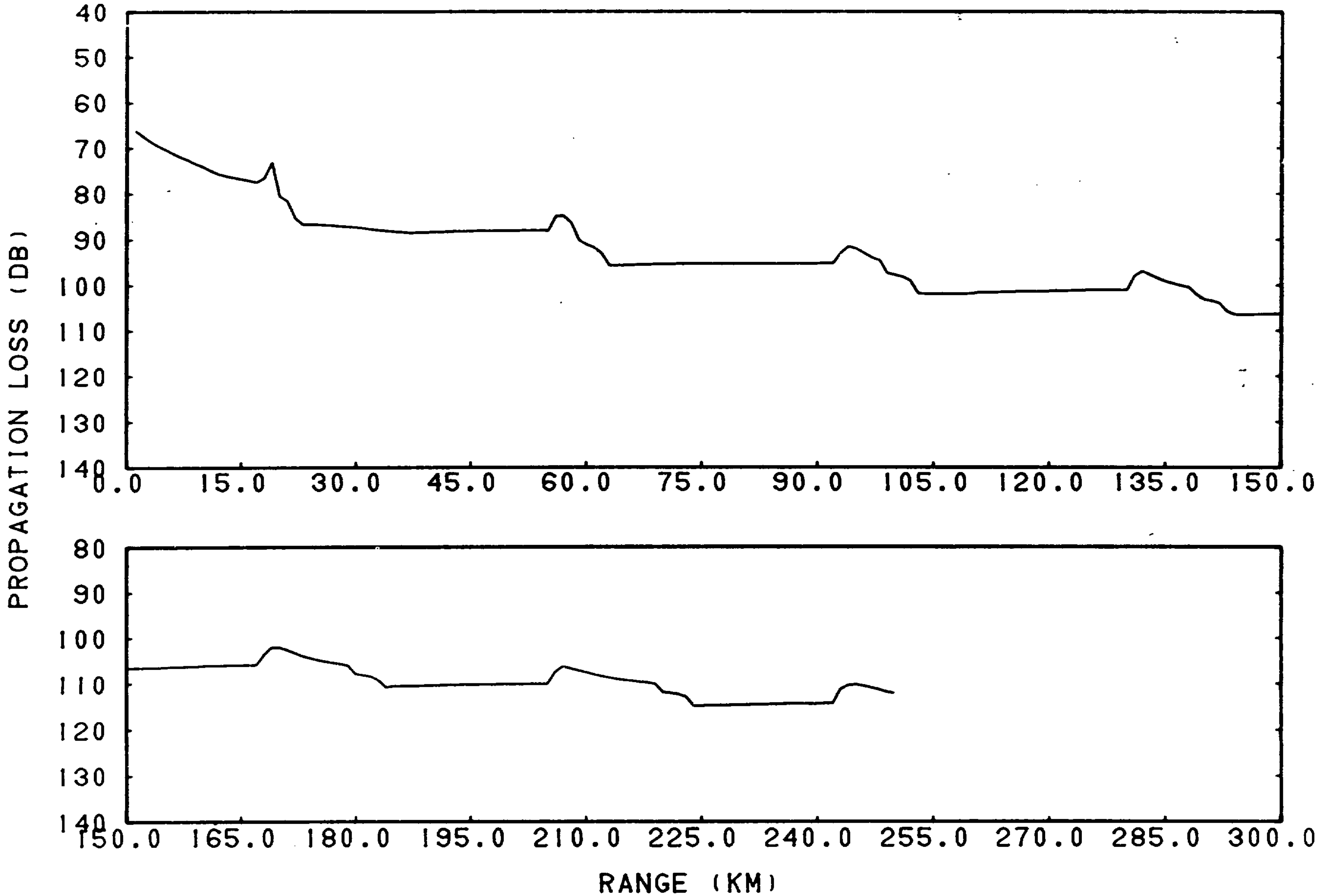
CONFIDENTIAL

(C) Figure IID-47. FACT Coherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 1685 Meters, Frequency = 290 Hertz



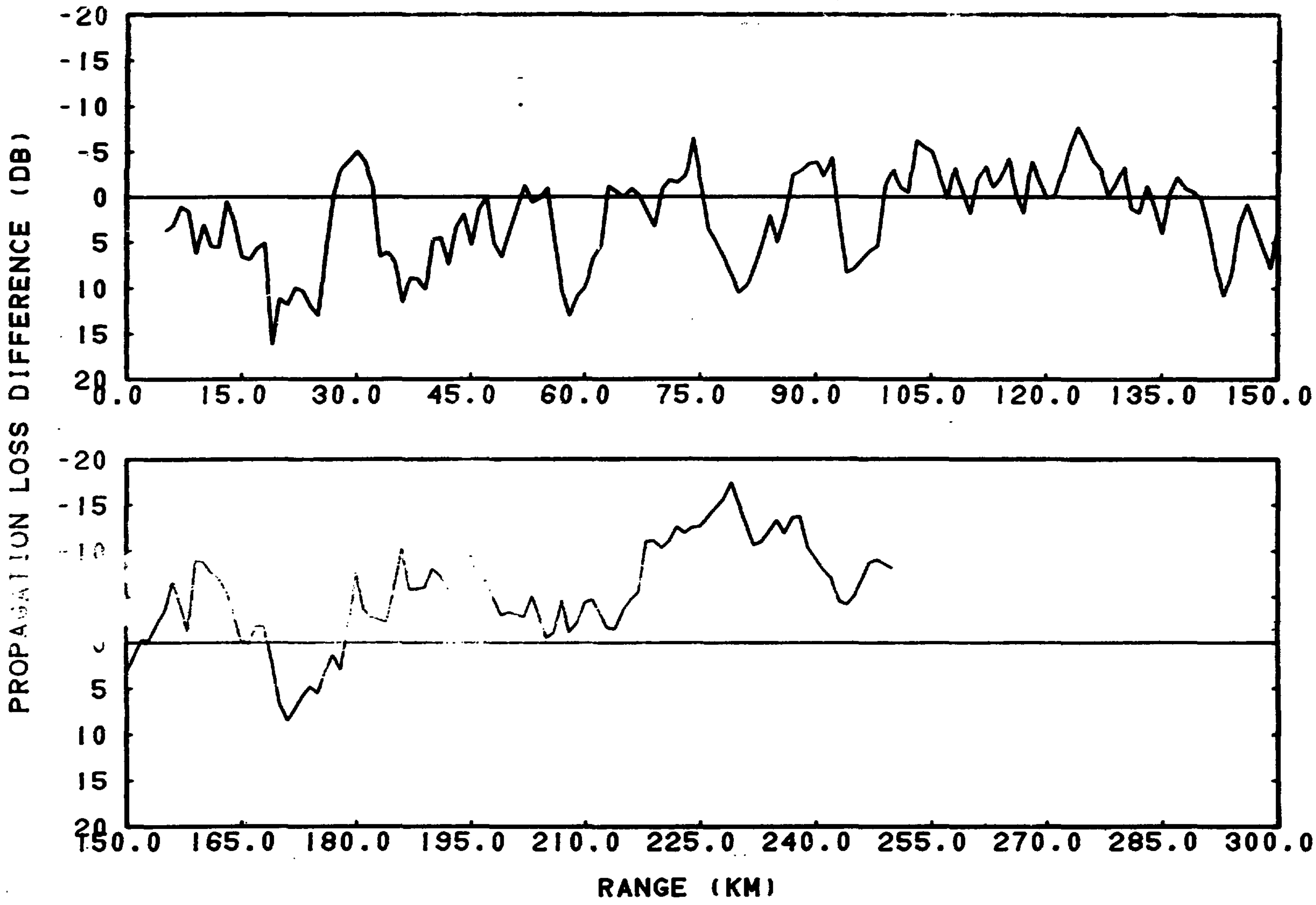
CONFIDENTIAL

(C) Figure IID-48. FACT Coherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 1685 Meters, Frequency = 290 Hertz, Subtracted from Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 1685 Meters, Frequency = 290 Hertz



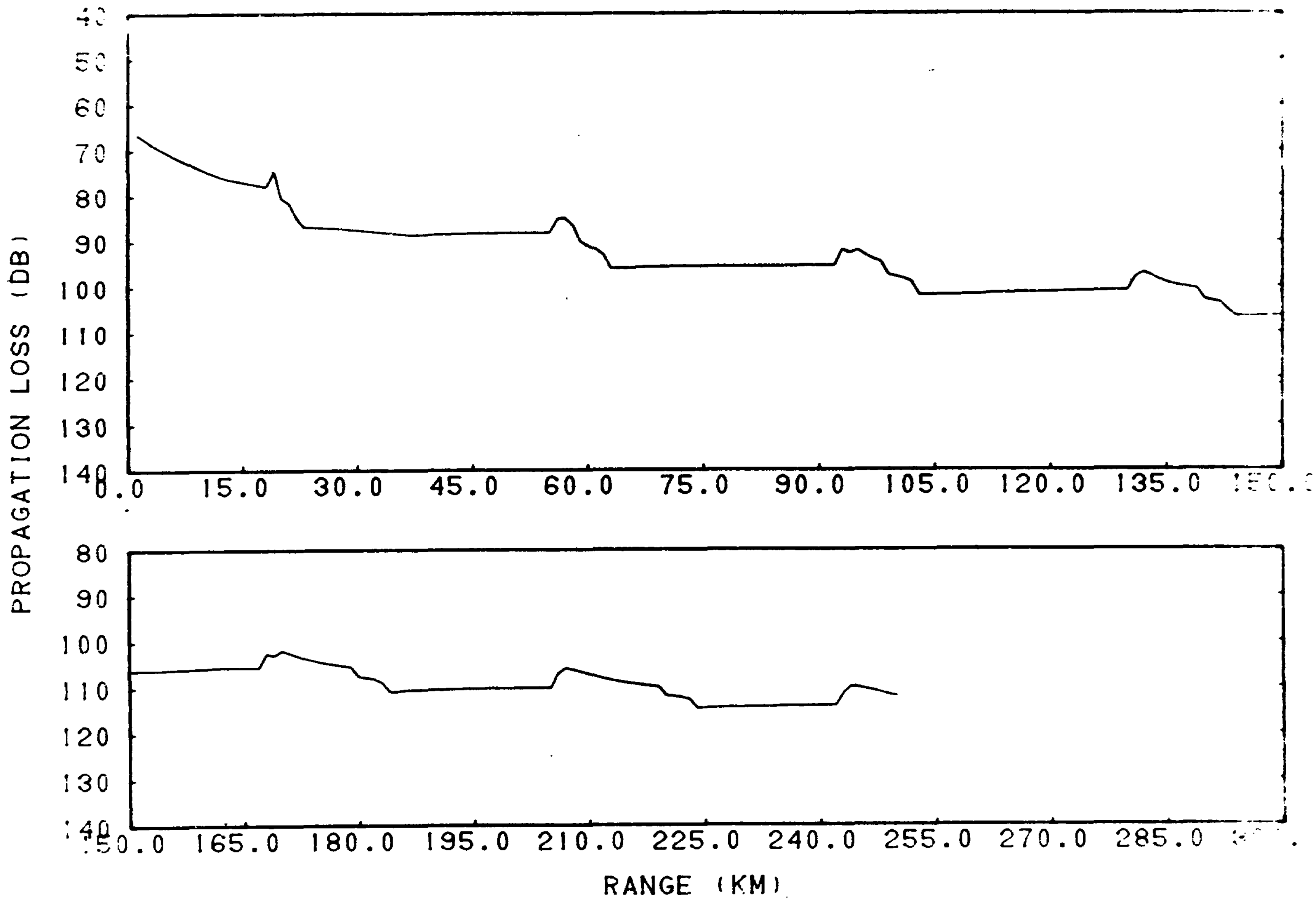
CONFIDENTIAL

(C) Figure IID-49. FACT Coherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3320 Meters, Frequency = 290 Hertz



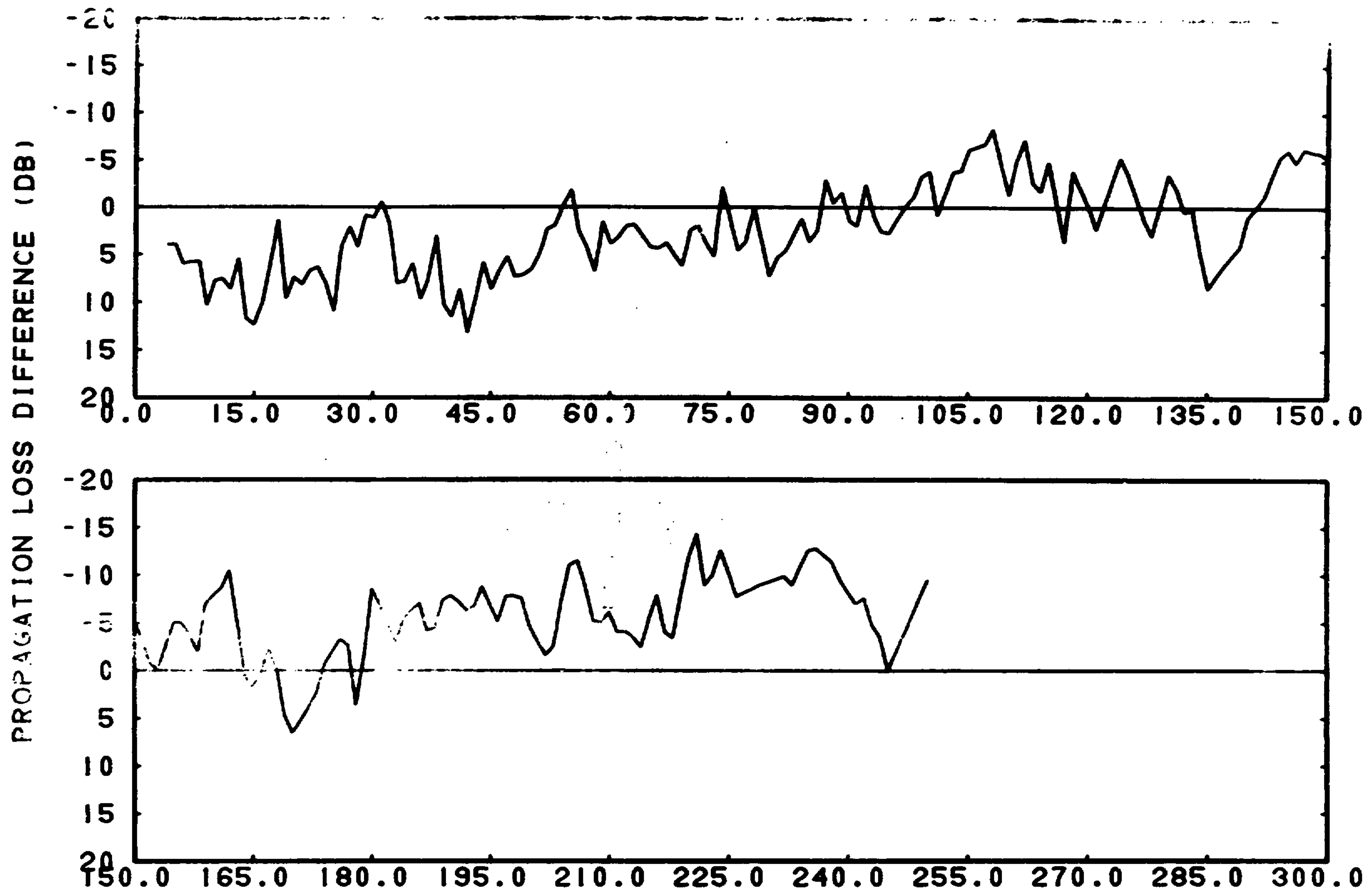
CONFIDENTIAL

(C) Figure IID-50. FACT Coherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3320 Meters, Frequency = 290 Hertz, Subtracted from Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3320 Meters, Frequency = 290 Hertz



CONFIDENTIAL

(C) Figure IID-51. FACT Coherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3350 Meters, Frequency = 290 Hertz



CONFIDENTIAL

(C) Figure IID-52. FACT Coherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3350 Meters, Frequency = 290 Hertz, Subtracted from Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3350 Hertz, Frequency = 290 Hertz

THIS

PAGE

INTENTIONALLY

LEFT

BLANK

DEPARTMENT OF THE NAVY
OFFICE OF NAVAL RESEARCH
800 NORTH QUINCY STREET
ARLINGTON, VA 22217-5660

IN REPLY REFER TO
5510/1
Ser 93/160
10 Mar 99

From: Chief of Naval Research
To: Commander, Naval Meteorology and Oceanography Command
1020 Balch Boulevard
Stennis Space Center MS 39529-5005

Subj: DECLASSIFICATION OF PARKA I AND PARKA II REPORTS

Ref: (a) CNMOC ltr 3140 Ser 5/110 of 12 Aug 97

Encl: (1) Listing of Known Classified PARKA Reports

1. In response to reference (a), the Chief of Naval Operations (N874) has reviewed a number of Pacific Acoustic Research Kaneohe-Alaska (PARKA) Experiment documents and has determined that all PARKA I and PARKA II reports may be declassified and marked as follows:

   Classification changed to UNCLASSIFIED by authority of Chief of Naval Research letter Ser 93/160, 10 Mar 99.

   DISTRIBUTION STATEMENT A: Approved for public release. Distribution is unlimited.

2. Enclosure (1) is a listing of known classified PARKA reports. The marking on those documents should be changed as noted in paragraph 1 above. When other PARKA I and PARKA II reports are identified, their markings should be changed and a copy of the title page and a notation of how many pages the document contained should be provided to Chief of Naval Research (ONR 93), 800 N. Quincy Street, Arlington, VA 22217-5660. This will enable me to maintain a master list of downgraded PARKA reports.

3. Questions may be directed to the undersigned on (703) 696-4619, DSN 426-4619.

Peggy Lambert

PEGGY LAMBERT
By direction

Copy to:
NUWC Newport Technical Library (Code 5441)
NRL Washington (Mary Templeman, Code 5227)
NRL SSC (Roger Swanton, Code 7031)
✓DTIC (Bill Bush, DTIC-OCQ)

Continuation of LRAPP Final Report, February 1972, Contract N00014-71-C-0088, Bell Telephone Labs, Unknown # of pages
(NUSC NL Accession # 057708)

PARKA II-A, The Oceanographic Measurements, February 1972, MC Report 006, Volume 2, Maury Center for Ocean Science (ONR), 89 pages
(NUSC NL Accession # 059194) (NRL SSC Accession # 85007063)

Project Pacific Sea Spider - Technology Used in Developing A Deep-Ocean Ultrastable Platform, 12 April 1974, ONR-ACR-196, 55 pages
√(DTIC # 529 945)

LRAPP Program Review at the New London Laboratory, Naval Underwater Systems Center, 24 April 1975, NUSC-TD-4943, Unknown # of pages
(NUSC NL Accession # 004943)

An Analysis of PARKA IIA Data Using the AESD Parabolic Equation Model, December 1975, AESD Technical Note TN-75-09, Acoustic Environmental Support Detachment (ONR), 53 pages
(NRL SSC Accession # 85004613)

Bottom Loss Measurements in the Eastern Pacific Ocean, 26 January 1977, NADC-76320-20, 66 pages
√(DTIC # C009 224)

PARKA I Oceanographic Data Compendium, November 1978, NORDA-TN-25, 579 pages
√(DTIC # B115 967)

Sonar Surveillance Through A North Pacific Ocean Front, June 1981, NOSC-TR-682, 18 pages
√(DTIC # C026 529)

The Acoustic Model Evaluation Committee (AMEC) Reports, Volume 1, Model Evaluation Methodology and Implementation, September 1982, NORDA-33-VOL-1, 46 pages
√(DTIC # C034 016)

The Acoustic Model Evaluation Committee (AMEC) Reports, Volume 1A, Summary of Range Independent Environment Acoustic Propagation Data Sets, September 1982, NORDA-34-VOL-1A, 482 pages
√(DTIC # C034 017)

The Acoustic Model Evaluation Committee (AMEC) Reports, Volume 2, The Evaluation of the Fact PL9D Transmission Loss Model, Book 1, September 1982, NORDA-35-VOL-2-BK-1, 179 pages
√(DTIC # C034 018)

The Acoustic Model Evaluation Committee (AMEC) Reports, Volume 2, The Evaluation of the Fact PL9D Transmission Loss Model, Book 2, Appendices A-D, September 1982, NORDA-35-VOL-2-BK-2, 318 pages
√(DTIC # C034 019)

DEPARTMENT OF THE NAVY
OFFICE OF NAVAL RESEARCH
875 NORTH RANDOLPH STREET
SUITE 1425
ARLINGTON VA 22203-1995

IN REPLY REFER TO:

5510/1
Ser 321OA/011/06
31 Jan 06

MEMORANDUM FOR DISTRIBUTION LIST

Subj: DECLASSIFICATION OF LONG RANGE ACOUSTIC PROPAGATION PROJECT (LRAPP) DOCUMENTS

Ref: (a) SECNAVINST 5510.36

Encl: (1) List of DECLASSIFIED LRAPP Documents

1. In accordance with reference (a), a declassification review has been conducted on a number of classified LRAPP documents.

2. The LRAPP documents listed in enclosure (1) have been downgraded to UNCLASSIFIED and have been approved for public release. These documents should be remarked as follows:

   Classification changed to UNCLASSIFIED by authority of the Chief of Naval Operations (N772) letter N772A/6U875630, 20 January 2006.

   DISTRIBUTION STATEMENT A: Approved for Public Release; Distribution is unlimited.

3. Questions may be directed to the undersigned on (703) 696-4619, DSN 426-4619.

BRIAN LINK
By direction

Subj: DECLASSIFICATION OF LONG RANGE ACOUSTIC PROPAGATION PROJECT (LRAPP) DOCUMENTS

DISTRIBUTION LIST:

NAVOCEANO (Code N121LC – Jaime Ratliff)
NRL Washington (Code 5596.3 – Mary Templeman)
PEO LMW Det San Diego (PMS 181)
DTIC-OCQ (Larry Downing)
ARL, U of Texas
Blue Sea Corporation (Dr.Roy Gaul)
ONR 32B (CAPT Paul Stewart)
ONR 321OA (Dr. Ellen Livingston)
APL, U of Washington
APL, Johns Hopkins University
ARL, Penn State University
MPL of Scripps Institution of Oceanography
WHOI
NAVSEA
NAVAIR
NUWC
SAIC

Declassified LRAPP Documents

Report Number	Personal Author	Title	Publication Source (Originator)	Pub. Date	Current Availability	Class.
NORDA35VOL.1BK 2OF3	Lauer, R.B.	THE ACOUSTIC MODEL EVALUATION COMMITTEE (AMEC) REPORTS, VOL. 2- APPENDICES A-D- EVALUATION OF THE FACT PL9D TRANSMISSION LOSS MODEL	Naval Ocean R&D Activity	810901	ND ADC034019	U
NORDA36VOL.3BK 2OF3	Lauer, R.B., et al.	THE ACOUSTIC MODEL EVALUATION COMMITTEE (AMEC) REPORTS, VOL. 3- APPENDICES A-D- EVALUATION OF THE RAYMODE X PROPAGATION LOSS MODEL (U)	Naval Ocean R&D Activity	810901	ND	U
Unavailable	Hooper, M. W., et al.	MEASUREMENTS AND ANALYSIS OF ACOUSTIC BOTTOM INTERACTION IN THE NORTHWESTERN MEXICAN BASIN	University of Texas, Applied Research Laboratories	811005	ADA107551	U
Unavailable	Kirby, W. D.	FINAL REPORT FOR CONTRACT NUMBER N00014-78-C-0862	Science Applications Inc.	820201	ADA111000	U
Unavailable	Brunson, B. A., et al.	PHYSICAL SEDIMENT MODEL FOR THE PREDICTION OF SEAFLOOR GEOACOUSTIC PROPERTIES	Planning Systems Inc.	820701	ADA119445	U
Unavailable	Cavanagh, R. C., et al.	NORDA PARABOLIC EQUATION WORKSHOP, 31 MARCH - 3 APRIL 1981	Naval Ocean R&D Activity	820901	ADA121932	U
NORDA34VOL.1A	Martin, R. L., et al.	THE ACOUSTIC MODEL EVALUATION COMMITTEE (AMEC) REPORTS, VOL. 1A- SUMMARY OF RANGE INDEPENDENT ENVIRONMENT ACOUSTIC PROPAGATION DATA SETS	Naval Ocean R&D Activity	820901	ADC034017; ND	U
Unavailable	Bartberger, C. L., et al.	THE ACOUSTIC MODEL EVALUATION COMMITTEE (AMEC) REPORTS, VOLUME 2. THE EVALUATION OF	Naval Ocean R&D Activity	820901	ADC034019	U
Unavailable	Deavenport, R., et al.	THE ACOUSTIC MODEL EVALUATION COMMITTEE (AMEC) REPORTS, VOLUME 3. EVALUATION OF THE RAYMODE X PROPAGATION LOSS MODEL. BOOK 2. APPENDICES A-D	Naval Ocean R&D Activity	820901	ADC034022	U
Unavailable	Unavailable	1975-1982 SUMMARY REPORT	Analysis and Technology, Inc.	821217	ADA192591	U
Unavailable	DeChico, D.	ACOUSTIC EVALUATION OF SANDERS ASSOCIATES ACODAC SENSORS	Naval Air Development Center	830301	ADB073873	U
NRL-FR-8695; NRL-8695	Palmer, L. B., et al.	TRANSVERSE HORIZONTAL COHERENCE AND LOW-FREQUENCY ARRAY GAIN LIMITS IN THE DEEP OCEAN	Naval Research Laboratory	830809	ND	U
Unavailable	Unavailable	ENGINEERING SUPPORT FOR ACOUSTIC AND ANALYSIS SYSTEM	Systems Integrated	840101	ADB091112	U
Unavailable	Unavailable	SEAS (SURVEILLANCE ENVIRONMENTAL ACOUSTIC SUPPORT PROGRAM) SUPPORT	Systems Integrated	840229	ADB091119	U